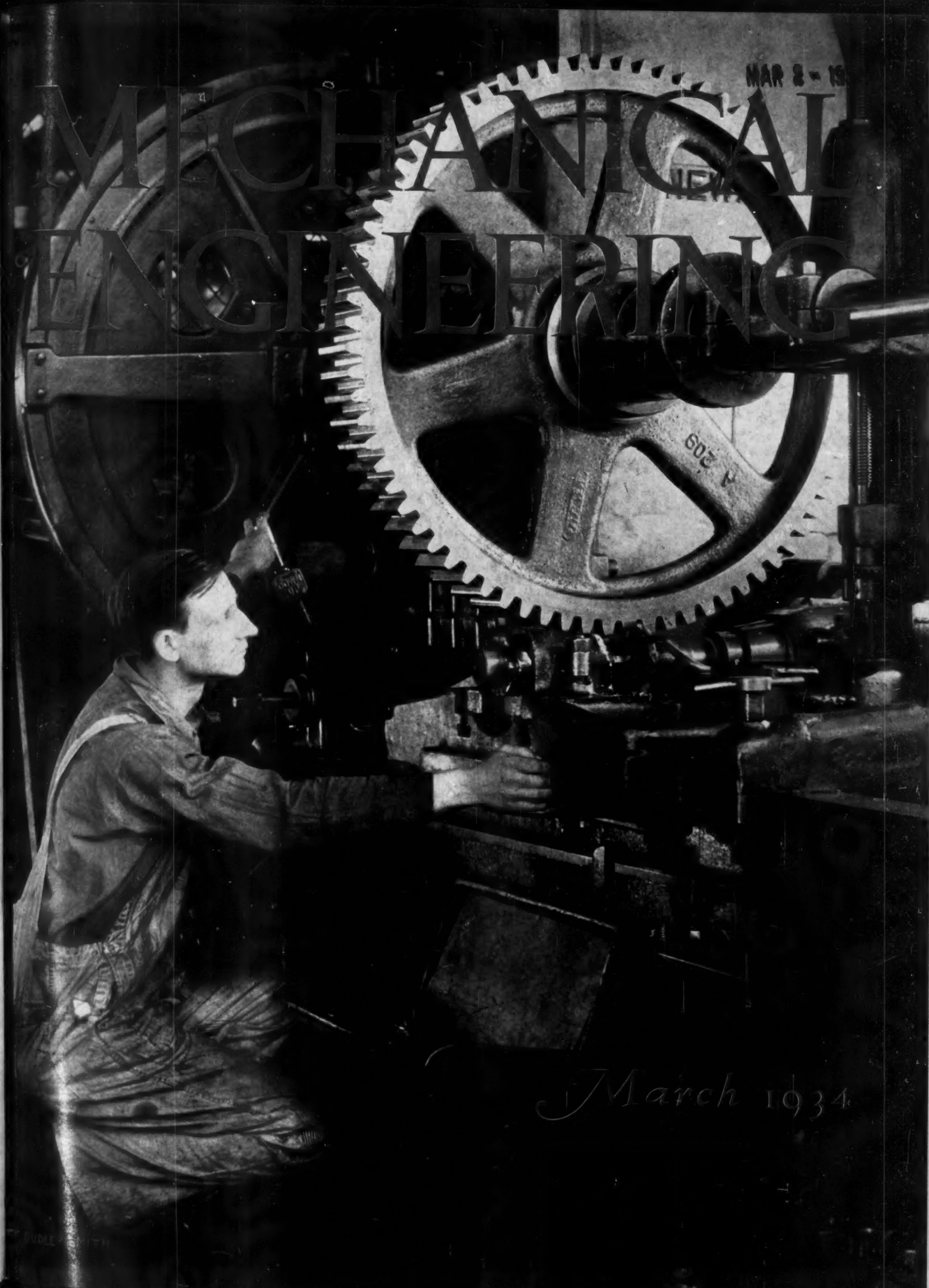
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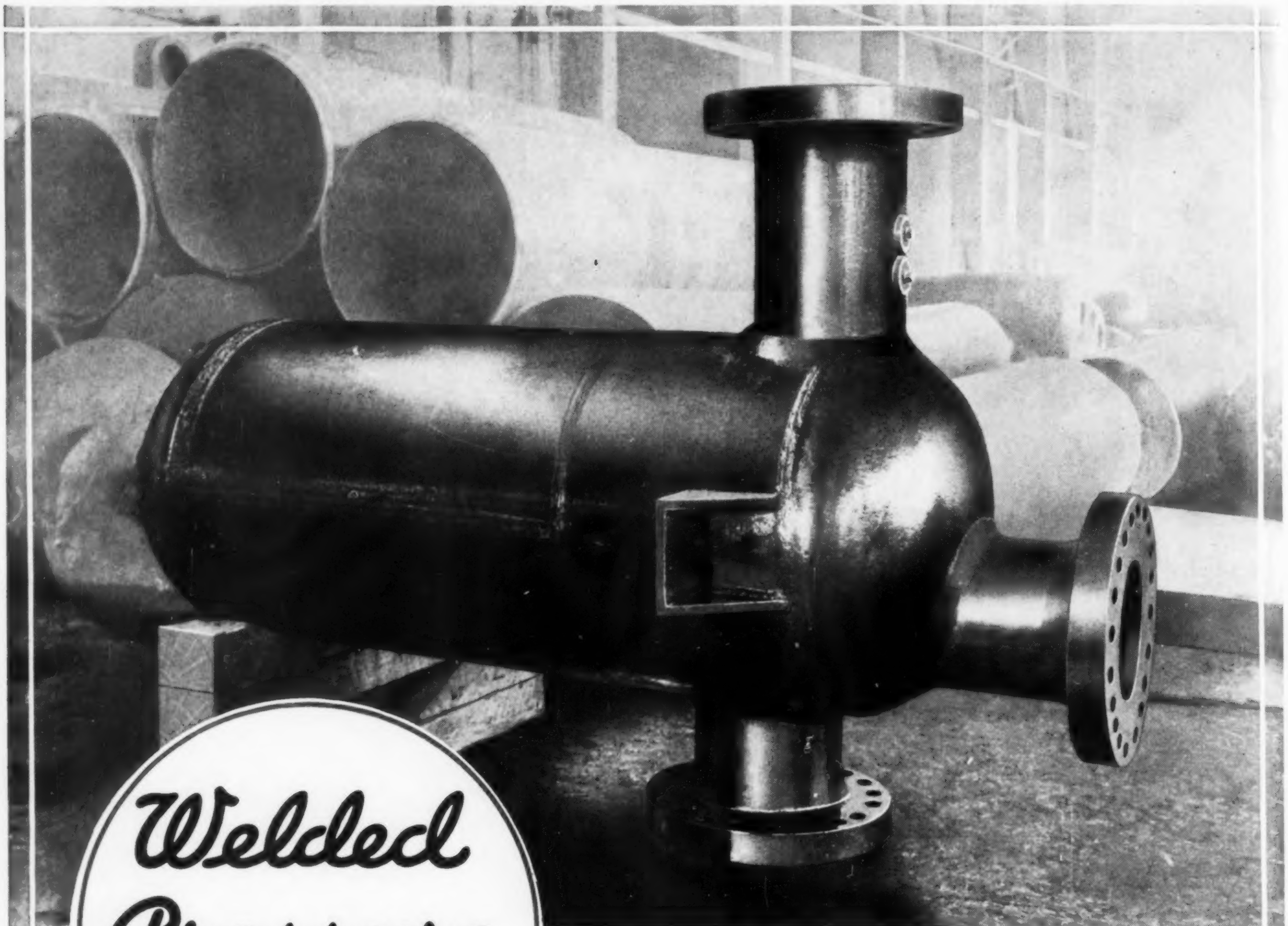

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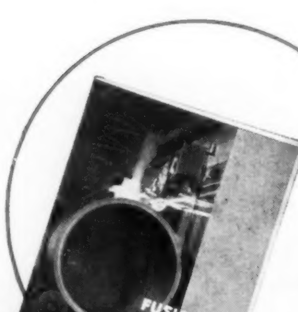

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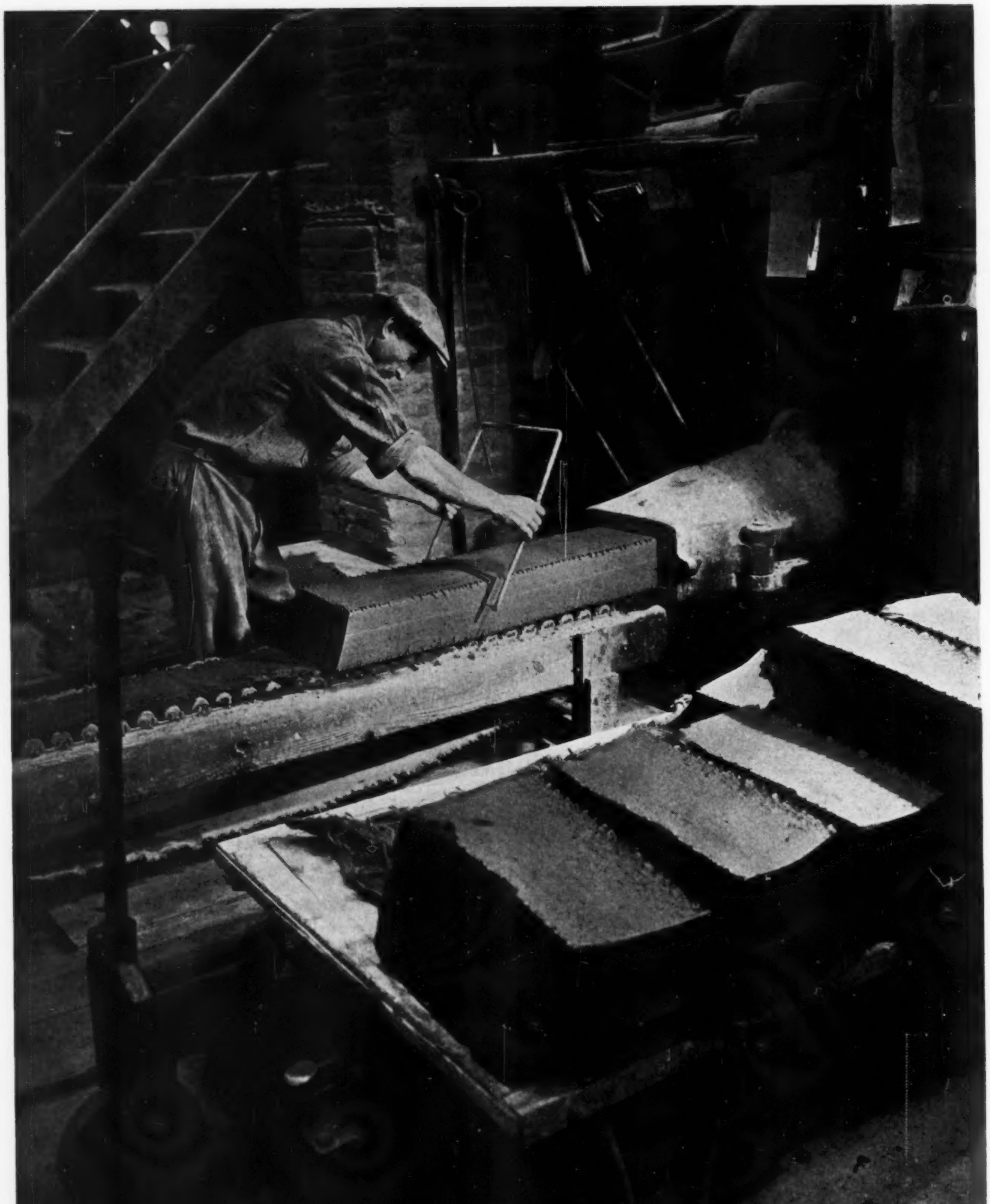


F. S. Lincoln

One of Man's Oldest Engineering Materials

The ENGINEERING-SCIENTIFIC APPROACH *to* CIVILIZATION

By HENRY A. WALLACE[1]

The Secretary of Agriculture Discusses the Social Advantages and Disadvantages of the Dilemma It Poses at the Annual Meeting of the American Association for the Advancement of Science.

I SUPPOSE you are all more or less familiar with that concept of the cyclical rhythm of civilization which has been popularized in recent years by Petrie, the Egyptologist, and Spengler, the German philosopher. According to this analysis, a civilization takes its origin in a profound, but as yet unexpressed, new attitude on the part of a virile, agricultural people toward the Universe. This profound, original feeling gives the bias to subsequent events throughout the life of the civilization. First, it manifests itself in great cathedrals and sculpture, next in painting, literature, and music, followed by science, mechanics, and wealth, and finally it manifests itself in dissolution which comes because of a lack of faith in the worthwhileness of the original attitude toward the Universe and because of disgust with the material results which have finally been inspired by that attitude. According to this analysis we have now come to the late fall, the eventide of this civilization, and the coming of the engineer is like the coming of Indian summer in late October just before the cold and dreary days of winter.

Philosophical analysis of this sort, even when backed up by archeological research, can of course be merely suggestive. But after our experience with the World War and the depression of the past four years, we are led to question the American credo, based as it has been on faith in progress unlimited, derived from endless mechanical invention, improved methods of mass production, and ever-increasing profits. Without accepting either the implicit pessimism of the Spenglerian twilight philosophy or the Pollyanna optimism of the old-fashioned American go-getter, I would ask you to examine superficially with me the contributions of science and engineering, the dilemma thereby created, and a possible way out.

For 100 years the productivity of the so-called civilized world has increased at the rate of about three per cent annually. Correcting for increase in population, the output per capita has increased at the rate of about one per cent annually. In the United States the rate of increase of material wealth has perhaps been a little faster than this. But everywhere there has been apparent a little slowing down during the World War and especially since 1930. And so we have, on the one hand, those people who proclaim that inevitably the pre-depression trend will be resumed, and those who, on the other hand, say that the time of the quantitative expansion of man's control over nature is now rapidly coming to a close.

Engineering and science, combined with the division of labor, have made it possible for an hour of man labor on the farm to produce several times as much as it did a hundred years ago. In company with the rest of you I have from time to time marveled over the tremendous contribution of the reaper, the binder, the combine, the truck, the tractor, and the gang-plow, but inasmuch as we have now come to days of real soul-searching about all the things which we have hitherto called progress, I think it is high time for all of us to analyze these various labor-saving devices a little more critically. Do they really save as much as appears on first glance?

True it is that the farmer puts in only a mere fraction of his own labor in producing wheat, as compared with 100 years ago, but what about the labor of the men who made the combines and the plows and the tractors? What of the labor of the men who transport the wheat the thousand miles to market, of the vast distributing and advertising machinery which seem to be necessary if we are to operate on the broad scale apparently required by the modern adaptations of engineering and scientific discoveries? Personally, I am inclined to think there is a real net gain, but it is a gain of a sort which can easily be lost altogether unless certain social adaptations are very rapidly perfected.

The change from the back-breaking cradle of our forefathers to the modern combine ought to mean a tremendous release of human energy on the farm for something besides growing and harvesting a crop. The days when wheat was broadcast by hand, perhaps from a saddle horse, in retrospect seem quite romantic, but to the farmer who had to spend days at seeding time where he now spends hours, the romance probably wore pretty thin. The grind of the harvest of years ago, the sweat of men in the field and women in the kitchen, was an honorable thing, and even celebrated in song and story; but it didn't leave much time for living. The engineers and the scientists have given us the instruments and the methods whereby we can escape much of the grind; theoretically, there ought to be far more time for living and far more with which to enjoy life. Yet the reverse seems to be poignantly true.

[1] Secretary of Agriculture, Washington, D. C.
An address before the American Association for the Advancement of Science, Boston, Mass., December 29, 1933.

The men who invented our labor-saving machinery, the scientists who developed improved varieties and cultural methods, would have been bitterly disappointed had they seen how our social order was to make a mockery of their handiwork. I have no doubt they felt they were directing their talents to free mankind from the fear of scarcity, from the grind of monotonous, all-absorbing toil, and from the terrors of economic insecurity. Things have not worked out that way.

MECHANIZATION HAS MADE NET GAINS

I do not mean to imply that there have been no gains. Of course there have been net gains, even if incommensurate with the hopes and promise of science. Plainly, we must hold those gains, and add to them rapidly and extensively. I think we can do this only if the planning of the engineer and the scientist in their own fields gives rise to comparable planning in our social world.

So far as science and engineering themselves are concerned, I see no reason why the rate of expansion which characterized the Century of Progress should not be increased, at least for a time. While there are certain ultimate limitations in our supplies of coal, iron, petroleum, and soil fertility, it is obvious to most of us who are close to any particular phase of scientific research or technical organization that there are imminent discoveries which, when applied, will increase per capita output enormously. Nearly every technical man knows in his heart that from a purely scientific, engineering point of view the most amazing things could be done within a relatively short period. Of course, in the world of hard fact the full effect of any revolutionary invention is not felt typically for 15 or 20 years. But I feel safe in saying that our scientists and inventors today have enough new stuff within their grasp or just around the corner so that the world 30 years hence could easily have a total productive power twice that of today.

It is almost equally possible that the total wealth-producing power of the world a generation hence will be less than it is today. The trouble, if it comes, will not be in the inability of scientists and technologists to understand and to exploit nature, but in the ability of man to understand man and to call out the best that is in him. In solving this limitation the scientists and engineers have all too often been a handicap rather than a help. They have turned loose upon the world new productive power without regard to the social implications. One hundred years ago the power looms of England destroyed the cottage weaving industry, and during the early years of that impact misery strode over the countryside of England in proportion as the *nouveaux riches* gained capital to exploit their gains over the entire world. That kind of thing has been done again and again, and we have called it progress because the power of man over nature was increasing and because in the long run the common man shared in this increase. What happened to the common man in the short run, of course, could be of no concern to a lassiez-faire society.

Most of us, whether scientists, business men, or laborers, have until recently looked back on the Century of Progress and called it good, but today the afflictions of Job have descended upon us and we must of necessity argue with Bildad, the Shuhite, and set ourselves right with our God before we go forward into a prosperity seven times that which we enjoyed before.

Acting perhaps in the capacity of Bildad, I would like to suggest that the very training which made possible the enormous material expansion of the past century may to some extent have made impossible the building of a just social system for the prompter and more uniform distribution of the wealth produced by the system. Most of the scientists and engineers were trained in laissez-faire, classical economics and in natural science based on the doctrine of the struggle for existence. They felt that competition was inherent in the very order of things, that "dog eat dog" was almost a divine command.

The power discovered by the scientists and inventors was applied in the United States by a race of men who had developed a concentrated individual will-power and an extraordinary thriftiness as a result of several generations of pioneer agricultural training and Protestant church-going. As a result, human power of high spiritual origin, but debased by the sophistication of the "devil take the hindmost" economics of the colleges, took command of the exploitation of the discoveries made by the scientists and inventors. The scientists and inventors have an intense kind of religion of their own—certain standards to which they like to be true—and as long as they could get enough money to pursue their researches, why should they care how some one else handled the social and economic power derived from these researches? Perhaps that is putting the matter unkindly, but other explanations that might be advanced are not much more flattering. Those who delved too deeply into social and economic problems got into trouble, and so many of the best scientists felt it was not good form to do things which to certain types of mentality seemed impractical and which might endanger science's financial support.

ECONOMIC BELIEFS OF ENGINEERS

It is my observation that previous to 1933 more than three-fourths of the engineers and scientists believed implicitly in the orthodox economic and social point of view. Even today I suspect that more than half of the engineers and scientists feel that the good old days will soon be back when a respectable engineer or scientist can be an orthodox stand-patter without having the slightest qualm of conscience. It is so nice to feel that there are great supermen from whom, directly and indirectly, you draw your own sustenance, who, sitting Jove-like above us lesser mortals, make possible the free functioning of the law of supply and demand in such a way that their profits enlarge at the same rate that our research expands. Like most of you in this audience, I rather like that kind of a world, because I grew up in it; in some ways, I wish we could get back

to it. But both my mind and my instinct tell me that it is impossible for any length of time. Of course, if prosperity returns within the next year or two, it is possible for us to think that we are back in that old world again. But unless the people who make profits and direct capital allocation to different productive enterprises have seen a great light, or unless we move forward into certain highly centralized forms of industrial and governmental control, we shall sink back into our former trouble.

ENGINEERS' SKILL IN PLANNING

There ought to be more than a little hope, it seems to me, in the fact that our engineers have demonstrated so successfully their skill in planning. In many great industries, the engineers have been able to mark out the contours of expansion and development 10 to 15 years ahead. If in the past they seemed to be guided by purely material and mechanical considerations, that has doubtless been because such considerations were necessarily the chief ones as long as we were conquering a continent. Today it is becoming increasingly evident that we must take into account the qualitative as well as the quantitative expansive aspects. This would suggest that in the engineering courses of the future the engineers should be given an opportunity really to enrich their minds with imaginative, non-mathematical studies such as philosophy, literature, metaphysics, drama, and poetry. Of course, as long as an engineer is burdened with the necessity of putting in 18 hours a day mastering calculus, mechanics, and the complex theories of electricity, he simply cannot give any effective attention to the cultural aspects of life. And if by accident an engineer, exposed to cultural studies, should be inspired by them, he might, for the time being, become somewhat less effective as an engineer. We are thus exposed to a dilemma, which I would be tempted to solve by saying that probably no great harm would be done if a certain amount of technical efficiency in engineering were traded for a somewhat broader base in general culture.

It is difficult to see how the engineer and the scientist can much longer preserve a complete isolation from the economic and social world about them. A world motivated by economic individualism has repeatedly come to the edge of the abyss, and this last time possibly came within a hair's breadth of plunging over. Yet science, all this time, has been creating another world and another civilization that simply must be motivated by some conscious social purpose, if civilization is to endure. Science and engineering will destroy themselves and the civilization of which they are a part unless there is built up a consciousness which is as real and definite in meeting social problems as the engineer displays when he builds his bridge. The economist and the sociologist have not yet created this definite reality in their approach; can you, trained in engineering and science, help in giving this thought a definite body?

Today, when the industrial nations of the world have skimmed most of the cream off the backward nations and the backward classes, and when there are no longer any challenging geographical frontiers to be conquered, it becomes apparent that we must learn to cooperate with each other instead of joining together in the exploitation of some one else. This means building a social machinery as precise and powerful as an automobile engine. How extraordinary is the patient vigor of thought which enables a group of engineers to blueprint and execute a new design. And how sloppy is our economic blue-printing and execution by comparison!

But it must be said in defense of the economists that their problem is infinitely more difficult than that of the engineer. The economic engineer has never had any excuse to exist until recently because no one gave him any orders for blueprints. Even yet the objectives are so loosely defined, the popular will is in such a state of flux, that the designing of the economic engineer is about like that of an automotive engineer who discovers after he has completed his engine that it was to go into a tractor instead of an automobile.

As I have said to many farm audiences, we are children of the transition—we have left Egypt but we have not yet arrived at the Promised Land. We are learning to put off the hard-boiled language of the past, but we have not yet learned to speak the cooperative language of the future. One is as different from the other as a human being is different from an animal. There need be nothing impractical, there need be nothing foolishly idealistic about a Christian, cooperative, democratic state. But I fear it will take us as long to build a public consciousness fitted to run such a state as it is taking the Russians to build efficient factories and train their people to run them.

BASIS FOR PLANNED ECONOMY

We know that there must be a balance between productive power and consumptive power, and that excessive profits used to expand productive power beyond consumptive power are sure to lead to a breakdown. We know that the continued insistence on heavy exports in excess of imports by a creditor nation is bound to lead to disaster. We know today that the great unemployment is in the so-called heavy industries, and that this could be remedied if faith in a profound new excitement swept the country like the railroad-building boom of the early eighties, or the automobile boom of the twenties. This boom might take the form of totally new railroad equipment, or the popularization of new and better airplanes, or the making fashionable of winter homes and winter industries for every one in the South and a duplicate summer set in the North. In any event, whatever is done to stimulate the heavy industries it is to be hoped that the bonds issued to pay for the stimulation will be on a long-term, amortized, low-interest basis.

We know that we must have a monetary system which will bring about a better balance between debtor and creditor and between productive power and consumptive power. These things can be measured and social ma-

chines can be built to deal with them, but before success can be expected, there must run through the rank and file of the people a feeling that amounts to a profound determination to deal with social problems.

There is something about engineering which tends to lay emphasis on logical, cold, hard, lifeless facts. Nearly all engineers have suffered the common punishment resulting from the remorseless discipline of higher mathematics, physics, and mechanics. No man has to work as hard in college as the engineer. As a result, the engineer sometimes imputes a value to precise mathematical reasoning which it does not always have. There is such a thing as life, and the mathematics of life is as far beyond the calculus as the calculus is beyond arithmetic.

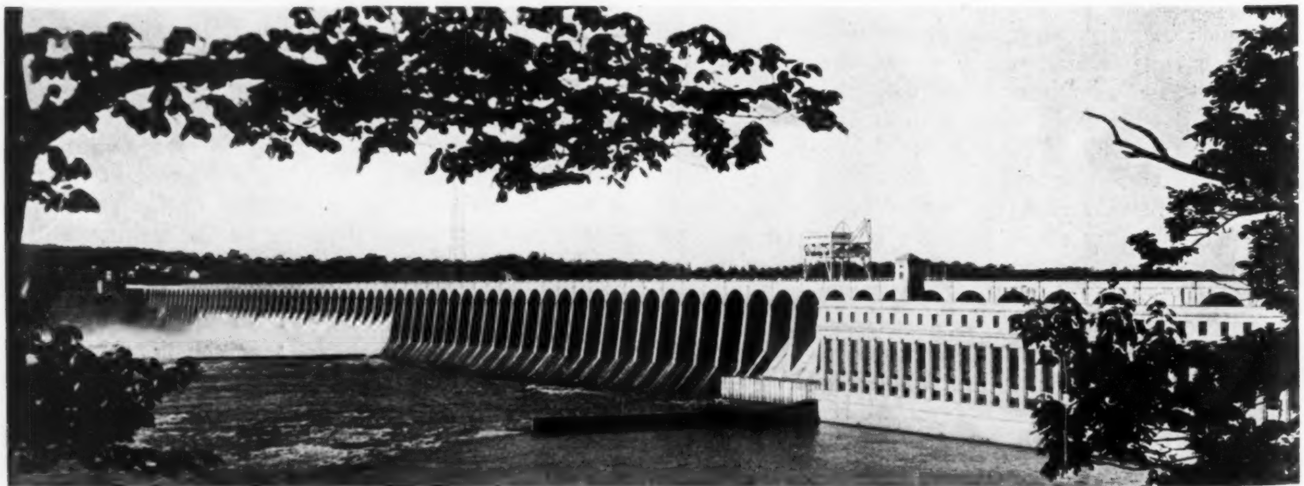
We can see in Mendelian genetics a complex algebra which has proved to be of some analytical use in determining the mechanism of heredity. Nevertheless, from the standpoint of producing superior plant and animal organisms, the engineering mathematical approach to life has not yet been especially successful. It seems to me that the emphasis of both engineering and science in the future must be shifted more and more toward the sympathetic understanding of the complexities of life, as contrasted with the simple, mathematical, mechanical understanding of material production.

The quantitative answers produced by the science of the past hundred years are not enough. They merely increase the speed of life without increasing the quality. Would that we had some one with the imagination of Sir Isaac Newton to develop the higher calculus of the engineering of life which is so necessary if our increased productive power is to increase total human happiness.

Haven't you sometimes wondered whether this whole Century of Progress might not be just a superficial and temporary phenomenon after all? The increase of physical output in three generations is so extraordinary that we've tended to think that this is what man is meant for. It seems to me a terribly inadequate yardstick of civilization. A man has food, clothing, and shelter; wherein does he differ from the beasts of the field? Surely these are not the things which distinguish the civilized from the uncivilized. Food and shelter and the other necessaries in any rational order ought to go without saying. They ought to be as automatic, and as universal, in this day of technological achievement, as the air we breathe. It is from this point on that life begins.

A characteristic of the engineer is his willingness to face the cold truth about the task to which he addresses himself. Engineers have brought to their jobs a more fully developed intellect than any other class of our citizenry. Sloppy, opportunistic thinking is simply inexcusable in the engineering world. I would be the last to suggest that the engineer abandon the precision of his thinking and his honesty in facing facts. I am merely asking that the same qualities be brought to bear in so far as possible on the more complex situations which have to do with living organisms and our social life. I fear, however, that in our social and economic life the objectives must always come from that mysterious realm which all engineers and scientists should treat with the greatest respect but with which engineering and scientific methods are totally unable to grapple.

In brief, then, we wish a wider and better controlled use of engineering and science to the end that man may have a much higher percentage of his energy left over to enjoy the things which are non-material and non-economic, and I would include in this not only music, painting, literature, and sport for sport's sake, but I would particularly include the idle curiosity of the scientist himself. Even the most enthusiastic engineers and scientists should be heartily desirous of bending their talents to serve these higher human ends. If the social will does not recognize these ends, at this particular stage in history, there is grave danger that Spengler may be proved right after all, and a thousand years hence a new civilization will be budding forth after this one has long lain fallow in a relative Middle Ages.



Galloway, N. Y.

WILSON DAM ON THE TENNESSEE RIVER

RAISING *the* FARM STANDARD *of* LIVING

By RALPH E. FLANDERS[1]

Under proper development, business must be expected to grow relatively to agriculture. Farmers producing under marginal conditions will be drawn into the more profitable operations of industry, thus reducing agricultural supply more nearly to fit the inelastic demand, and raising prices in the process.

This is the natural, unregimented remedy. There are two new elements which we must introduce into it. We must not permit the emigrating farmer to cut the vital cord which connects him with the land. The expansion of industry should be encouraged to take place in decentralized areas in which subsistence homesteads can be occupied by the newly recruited industrial workers. The advantages of this policy are so many and so obvious that they need not be detailed. The future of the subsistence-homestead project lies in the movement from farm to factory, not from factory to farm.

The other essential is that we stabilize our industrial operation.

A HIGH SCALE of living and a reasonable stability of that scale are the twin objectives of our social and economic exploration. If we seek stability alone, we do not have to search far. It is to be found in subsistence agriculture, which, however, does not offer a very high standard. If it is a high standard we seek, it is to be found in modern industry, in those brief periods in which it is functioning to its full capacity. Such full functioning is not, alas, related in any way to stability. We thus find the twin objects of our search in disjointed areas. It would seem logical to accomplish their desired union by setting up some effective connection between stable agriculture and productive industry which will unite and preserve the good qualities of each.

SUBSISTENCE AGRICULTURE

The stability of subsistence agriculture has been largely conditioned hitherto by the weather. Science and engineering have contributed toward mitigating the destructive influences of drought by developing tools and methods for dry farming, by installing irrigation systems, by developing drought-resisting varieties of plants, and in other ways. In addition, the development of transportation has made it possible to bring food supplies into drought-stricken areas from unaffected regions so that actual famine is no longer to be feared in civilized nations.

Science and engineering have done much more than this in the matter of increasing farm productivity. The details of its improvements are commonplace. It has raised production per acre by crop rotation, fertilization, new varieties, and intensive cultivation. It has even more radically increased the farm output per man by the mechanization of almost every farm operation, with the added effect of releasing for cash crops farm land formerly required for feeding draft animals.

Since this mechanization invites specialization in product, the tendency has been for the farmer to devote himself to the raising of the agricultural staples, ranging from milk and milk products to lard, wheat, and cotton. The latter are subject to international markets, made possible by the cheap transportation of railroads and steamships, and by the rapid spread of crop and price information through the telegraph, telephone, cable, and radio.

New conditions are the net result of this impingement of science and engineering on agriculture.

Subsistence agriculture in anything approaching a pure state has disappeared except in the social backwaters of the less fertile regions, and among a small class by whom farming is intelligently accepted as a way of life.

Subsistence agriculture as a basis, with a cash crop as a means for raising the standard above the subsistence limit, is being practised by a class of farmers that is comparatively small, but that is growing in members and in the success of its operations.

The farming of staple crops with world-wide markets, often without a subsistence basis, remains the largest element in agriculture. It is the branch with the largest hopes of profit and the least hope for stability. It is the element, therefore, which requires the most consideration.

INSECURITY OF AGRICULTURE ON A NON-SUBSISTENCE BASIS

When agriculture leaves its subsistence basis and risks all on a staple crop, it abandons its original characteristics and takes on those of an ordinary business, with all of its risks and anxieties, and with at least the same risk of out-and-out business failure. This the farmer has been slow to realize, as he has carried his stable

[1] President, Jones & Lamson Machine Co., Springfield, Vt. Mem. A.S.M.E.

An address before the American Association for the Advancement of Science, Boston, Mass., December 30, 1933. (Except where otherwise noted photographs are from Galloway, N. Y.)

subsistence psychology over into his hazardous and unstable internationalized industry.

His new conditions are even more hazardous than those of other occupations.

The business world has always been free with its advice to the farmer, and this advice has generally been to carry on his occupation on "business principles." The idea is wide-spread that the farmer is fundamentally unbusinesslike, and suffers properly for his sins. But it is difficult to get these admonitions out of vague generalities into specific recommendations; and the more the adviser studies the problem the less ready he will be with his advice.

There are several reasons why the modern farmer cannot be "businesslike" in the sense that a manufacturer uses the term. One quite obvious reason is the weather, already mentioned. The manufacturer is subjected to disturbing variations in general business, and adapts himself to them with such patience as he can muster—with too much patience, if anything. The farmer is, in many of his crops, subjected to the same variations, but has these additional elements of heat, cold, rain, drought, tornado, and hailstorm to contend with. It is difficult to predict the weather far in advance, and impossible to control it.

Another handicap is that of an ***inflexible market*** for most of the staples. Take a hundred dollars off the price of a low-priced car and you may double the sales. Cut the price of wheat in two and the demand does not greatly increase. Some elements of the earth's population may shift to a certain extent from rye to wheat in such a case; some other regions in which poverty and numbers prevail may increase their consumption; there may even be an extended use of the cereal for feeding cattle and fowls. But all of this will not proportionately increase the demand. With all of our distresses and with all of our dissatisfactions, the nations which form the wheat markets of the world do not go hungry in the mass, so that almost the only way to take care of a large increase of this staple is to waste it. This condition marks a gain in general well-being, but it does not help the farmer.

Again, while industries may profit by a tariff, this is a doubtful resource for the staple farmer. The sudden onslaught of a fine crop season may easily produce a surplus over that which will be absorbed by the inflexible home market. In such a case it is the exportable surplus, whose price is at the mercy of world markets, which determines the domestic price, tariff or no tariff. This time-honored expedient fails the farmer just when it is most needed.

This leads to another difficulty, and that is the problem of controlling the output. A manufacturer can decide instantly to increase or decrease his output and usually can put his decision into effect within a few days, or even hours in some cases. Not so with the farmer. There is just one time in the year when he can determine the acreage to be devoted to this crop and that. It can be done at planting time and at no other time. And that does not determine output, for there is still the weather. A manufacturer who had as little control of his output as does the farmer would go slowly but irrevocably insane.

There are several avenues of escape from this tangle of circumstance in which the farmer finds himself, and a few of them are here noted and discussed.

A resource which lies within the occupation itself is a general dependence on the second type of agriculture described above—a subsistence basis for stability and a cash crop for raising the standard of living. This is the pattern into which staple agriculture must be encouraged, urged, or forced by all available means. Much

progress is being made, as for instance among the cotton croppers of Texas. Continued progress will effect continued improvement.

Another resource, now being tried, is the subsidizing of agriculture by grants from industry in the form of processing taxes. While this carries with it provisions for a decrease in production, it is in other respects quite parallel with the subsidies to the industrially employed through the various agencies established for the purpose. On a large scale it can be submitted to only as an emergency measure.

As a more fundamental and permanent solution a favorite proposal is that of enlarging international commerce to promote a greater inflow of desired goods to finance an outflow of our farm products. There are possibilities in this, but they seem to be limited. The world is, at present, under the action of natural forces, reorganizing itself into natural economic empires, of which we are one self-contained unit. Any attempt to break across this organization on a large scale will meet with serious difficulty. And after the end is accomplished, there is little in the accomplishment which relieves the natural hazards of the international market for staples. Its variations would simply affect our own agriculture on a larger scale.

Perhaps the chief objection to this way of escape appears if we examine the policy in what would seem to be its most nearly perfect form. Here in the United States we have food raising on a vast scale and ultimate possibilities of doubling or tripling the output. We have ample mineral resources as well. In China there is a large population suited to industry, with moderate mineral resources and a quite inadequate food supply. What more natural than that American agriculture should increase to feed the Chinese population, and that Chinese industry should grow to supply the American population?

There are numerous interesting side issues in this proposal, but its main elements are the important ones. Such an arrangement would be unfortunate for both nations.

With an ample food supply from the outer world assured, China would at once proliferate in its industrial population to match the increased supply. This would put her so far beyond her own resources that the physical existence of the millions of its new population would depend on this trade interchange, and its interruption for any length of time by political overturns or by warfare would undoubtedly involve death on an unprecedented scale.

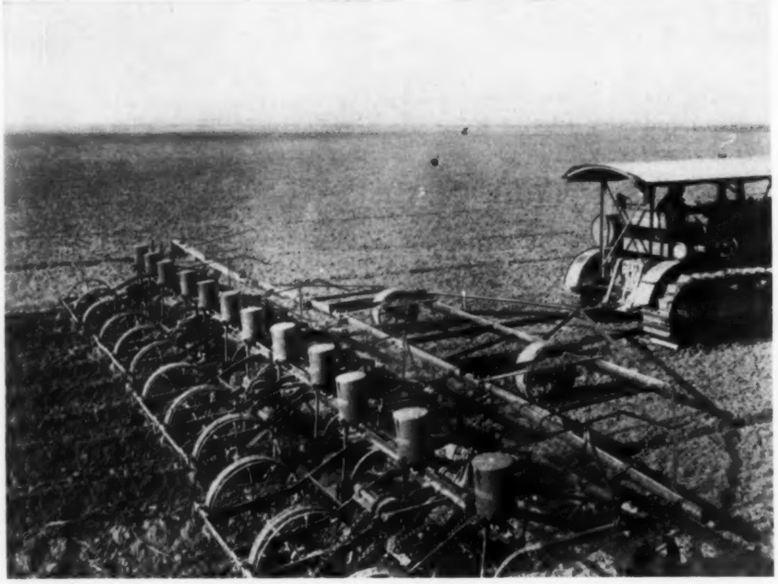
For our agriculture the dangers are not so serious. The interruptions of politics and war would be no greater than they have been in the past, except as they would affect an expanded farm population. The principal danger would lie in tying our agriculture in with the fortunes of a foreign industrial ally. In the past the agricultural partner has tended to get the shorter end of the returns from the partnership. There is no reason to believe that conditions would change in the future.

The real safety of agriculture lies in some natural check on its productiveness as compared with the demands of its market, and to me the best hope for this event lies in an economy which, while not rigidly national, still looks to self-reliant policies for its own salvation. Briefly, the remedy would seem to lie in a new re-alignment of agriculture and industry.

Continued improvement in machinery, processes, and management will operate, as in the past, to increase the spread, in a favorable sense, between wages on the one hand, and the prices of consumer goods on the other; in other words, it will raise the standard of living, which has never been anything but miserably low for millions of

willing workers, even in our periods of greatest prosperity.

But how does this affect agricultural income? It will do so in two ways—by lowering relatively the prices of goods which the farmer buys, and by raising relatively the prices of the products he sells. It can effect this spread more surely than it can be accomplished by any imaginable monetary policy, and on a more permanent basis than by any elaborate mechanism of control.



Prices of goods purchased can be lowered for the farmer as for the worker by encouraging the progress of improvement in industrial production instead of discouraging it.

The process of raising the prices of farm produce is more indirect but is fundamentally sound. Farm produce is largely, though not entirely, composed of items of comparatively inelastic demand. The products of manufacture are largely, though not entirely, composed of elements which have a very elastic demand, contributing to unsatiated desires of masses of unsatisfied people. Under proper development, business must therefore be expected to grow relatively to agriculture. Farmers producing under marginal conditions will be drawn into the more profitable operations of industry, thus reducing agricultural supply more nearly to fit the inelastic demand, and raising prices in the process.

This is the natural, unregimented remedy; and it applies as well to other overdeveloped occupations, such as that of soft-coal mining, whose problems will never be settled with the best will in the world until the number of miners is reduced.

This remedy, by suction from an overdeveloped agriculture into a developing industry, is a natural one. Under temporary conditions it has been very rapid in the past. There are two new elements which we must introduce into it.

In the first place we must not permit the emigrating farmer to cut the vital cord which connects him with the land. The expansion of industry should be encouraged to take place in decentralized areas in which subsistence homesteads can be occupied by the newly recruited industrial workers. The advantages of this policy are so many and so obvious that they need not be detailed. The future of the subsistence-homestead project lies in the movement from farm to factory, not from factory to farm.

The other essential is that we stabilize our industrial operation. The requirements of industrial hygiene are no longer shrouded in complete mystery, even though the achievements of industrial medication and surgery still remain dubious. To suggest the progress of our knowledge in this respect would require another paper, and another occasion.

Let me conclude by emphasizing those elements in it which describe the common interests of industry and agriculture. And let me urge that those interests be examined and appropriate action taken.

Wide World Photos

The ENGINEER *and* LAND USE *in* MASSACHUSETTS

By HUGH P. BAKER[1]

WITH THE settlement and organization of the Massachusetts Bay Colony and with the grant and sale of lands, land use which has continued until today began its progress.

For the first 300 years in the life of the Commonwealth there was very little serious misuse of the forest. The forest was an important and, more, a necessary factor in the settlement of the land. It had to be cleared away that the soil might be tilled and it was used for the building and furnishing of homes and for fuel and for other purposes, even for the production of pearl ash which was shipped in large quantities to Europe.

EXPLOITATION OF LANDS AND FORESTS CAME WITH GROWTH OF CITIES

Not until the rapid growth of the cities up and down the Atlantic Coast was well under way, through the first half of the last century, did there come a period of serious exploitation of the forests of the state. Logging and lumbering then began in earnest, and the limited size of the state meant that the period of exploitation was short. Finally, in the late eighties and early nineties, with increasing prices of lumber and with increasing observation of the destructive effects of deforested hills and slopes, there began gradually a period of forest renewal.

Along with the use of the forest as a phase of land use, of course, went the use of the soil for agriculture. Hills and steep slopes were cleared and farmed and these farms produced men above all things. Gradually, with the opening up of the richer soils of the West, there began an abandonment of farms in Massachusetts; and the most significant thing in Massachusetts agriculture in the last 75 years has been the changing use of land. In 1880, 41 per cent of the state was enclosed within farms. In 1930, 14 per cent. In other words, in a period of 50 years nearly one million acres of land underwent a decided change in so far as use was concerned. The result of this changing use of land is that today more than 65 per cent of the land area of the state is not used for agriculture and has come to be recognized as much a problem of land use as the right development of agriculture itself.

On the 35 per cent of the state still enclosed in farms, the practise of agriculture has changed almost fundamentally in the last 50 to 100 years.. Staple crops for national markets, such as grain, beef, and hay, are no longer produced, so that the agriculture of today in Massachusetts consists largely of producing food crops for nearby urban populations. We have come to be a producer of such specialized crops as dairy products, fruit, poultry, vegetables, and tobacco. While agriculture in Massachusetts has been undergoing constant change, there has never been and cannot be at this time any question as to the permanency of agriculture in the state. A significant development has been the increasing number of small pieces of land occupied for what might be called part-time farming or gardening by families living in villages or engaged in industry. More than 60,000 of such small pieces are now being occupied and used and there is every indication that this number will increase largely within the next few years.

Any discussion of land use in Massachusetts must, in view of the changes which have taken place in the forest cover, in agriculture, and in the use of land, involve much more than agriculture and much more than forestry simply as a means of producing wood. Massachusetts has before it a great opportunity in the development of its non-agricultural areas, largely through forestry, for the conservation of water, for recreational purposes, including the producing of fish and game, for stabilization of employment, and for the intangible but no less important value of increasing the beauty of the landscape of the state. Because of the opportunity with which the state is confronted in the development of all of its land area, there is great need for more definite information as to needs and opportunities. It would seem as if the state could well undertake a land economic survey which would bring out the facts needed as to all of those values which may accrue to the state from complete and satisfactory land use.

ENGINEERING PRINCIPLES WILL BE IMPORTANT IN LAND USE IN THE FUTURE

As engineering principles have always been used in agriculture and in the utilization of the forests and as many of the developments which must take place in land use in Massachusetts involve much more than agriculture, it would seem that the engineer must have an important part in land use in the future. The part he may play in land use in Massachusetts would apply throughout New England and the nation.

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[1] President, Massachusetts State College, Amherst, Mass.

From an address before the American Association for the Advancement of Science, Boston, Mass., December 30, 1933. Abridged.

NOTE: The omitted portions of this address dealt with the Land Grant Colleges and engineering in Massachusetts and a brief historical résumé of the application of engineering to land use in that state.—EDITOR.

There is every indication that land use in the broader sense in the state must proceed along three parallel lines, agriculture, forestry, and recreation. As we go forward in more effective land use, the engineer could well have a very definite place because there is involved in all of these parallel lines of development (1) transportation and communication; (2) water power and power distribution; (3) drainage, water conservation, and irrigation; and (4) sanitation and housing improvement for those who will live on the land.

SERVICES THAT THE ENGINEERS CAN RENDER IN AGRICULTURE AND IN FOREST AND RECREATIONAL AREAS

Again, speaking from the standpoint of agriculture and forestry, it is in place to emphasize the importance and more the need of the engineer in land use in Massachusetts. To be more specific:

(*a*) On land devoted to agriculture he has the problem of land drainage, irrigation, and terracing. In providing power and light on the farm it is essential that such use of light and power shall be developed that farm life will be made more attractive. Along with these developments there must be provided for the farm adequate water supply and proper sewage disposal. The planning and construction of the best type of farm home which the farmer's funds can provide is a direct challenge to the engineer. The development of other farm buildings suitable for various farm enterprises is a continuous job to keep step with changes in farm practises. The development of fire-resistant construction and the means for fighting fires on the farm are not only of very great importance to the farmer, but to the community and the state.

(*b*) On the areas to be devoted to forests the engineer has the problem of water conservation, involving as it does the important question of flood control; the utilization of water power; the building of roads, trails, and telephone lines; and the problems involved in the restoring of small wood-using industries to the state and the more effective use of wood and other products of the forest.

(*c*) On areas devoted to recreation, the engineer is faced with the challenge of the construction of parks and play areas with all that that means in providing adequate water supplies, means for sewage disposal, construction of shelters and other buildings, the improvement and beautification of streams, and the building of roads, trails, artificial lakes, and ski and toboggan runs.

As industry through years of painful experience is beginning to learn that competition is not the life of trade but rather that cooperation is essential to success, so we are beginning to see that in the solution of numerous problems of agriculture and forestry, cooperation is needed not only among the Federal Government and the farmer and the land owner, but among the farmer, the forester, and the engineer. Unfortunately, and as he is looked at from the farm and the forest, the engineer has too often in the past been somewhat indifferent to the problems of the farmer and the forester because perhaps he has felt that there were other more important and more definite engineering opportunities before him. The farmer and the forester are now ready to say to the engineer that there are no more important problems before the state and the nation than the gradual bringing about of complete and satisfactory land use with all that that will mean to the improvement of our economic and social life. The farmer and the forester are confident that the engineer will accept the challenge of cooperation for the solution of a great national problem.

Nesmith, N. Y.

MANUFACTURING COSTS *and* PRICES *Under the* NRA

Showing That 25 × 4 = 100, But (9 × 4) + (32 × 2) = 100 Also

By WILLIAM D. ENNIS[1]

THERE is a general impression that the National Industrial Recovery Act forbids selling at less than cost. The explicit terms of the act contain no such precise stipulation. Section (1) declares it to be the policy of Congress "to eliminate unfair competitive practises." Under Section (4) the President has power to prohibit "destructive . . . price cutting." Official pronouncements of NRA authorities support the public assumption, but have only presumptively the force of law. The President's Blanket Code practically ignores the matter and is preoccupied, rather, with the danger of profiteering. It stipulates that prices must not be *raised* to an extent greater than the actual increase of cost. It requires that due weight be given to probable increases in sales volume. A ruling on Clause (9) says: "Where the July 1, 1933, price was a distress price, the employer signing the agreement may take his cost price on that date as the basis" for an increase in selling price not in excess of the increase of cost.

Various approved codes, however, specifically forbid selling below cost. The following discussion considers, from the standpoint of code drafting and otherwise, two questions:

(*a*) What is "selling below cost?"
(*b*) Is it wise and practicable to forbid it?

WHAT IS SELLING BELOW COST?

At the beginning, there was a general (although not universal) impression that the cost implied in this prohibition was the *individual* producer's cost. A bulletin of the Chamber of Commerce of the United States, June 29, spoke of agreements "not to sell below cost (individual cost)." Still earlier, the National Association of Manufacturers defined unfair competition as including selling "below reasonable cost," with the suggestion that "it might . . . be provided that no producer shall sell below his own cost of production."

It seemed, in fact, that individual cost *must* be intended. No other position was tenable. If by "cost" were meant the lowest cost of production, many producers could sell at a loss. If highest cost of production were meant, there would be no profit to the public or to any producer resulting from his exceptional efficiency. If average cost were meant, both evils would result at once. (The N.A.M. suggested rather cautiously that the "mode"—maximum frequency—cost might be approved as reasonable.) And what is average cost? The presumed decision that the individual producer's cost was to govern was a wise one. Under such decision, competition in efficiency remains possible.

But in an address by Malcolm Muir, then Division Administrator of the NRA, before the New York State Society of Certified Public Accountants, October 30, it appeared that a high-cost producer might sell at prices below his individual costs. Mr. Muir says, "In the majority of industries . . . a manufacturer must not sell below his own costs—provided, however, that he can sell his products at a price which will enable him to meet the competition of another producer. . . ." More recently, James Hughes, of the NRA Economic Research and Planning Division, is quoted as warning against "individual company cost" prices in codes. Allowing one man (the quotation proceeds) to sell a product at 90 cents, his cost, while requiring a higher-cost employer to charge $1 for the same article, would have the effect of "legislating a competitive advantage."

This seems to require that both sell at the same price, although it is not clear which price (90 cents or $1) is meant. The code for the salt industry implies that 90 cents is to be the price: "No producer shall sell at a price . . . less than his current cost of production or the current cost of the lowest cost producer in the field. . . ."

The wisdom of the prohibition of selling below cost is more or less contingent on its legality, and that is still to be determined. And if the question of whose cost is to be determining is for the moment set aside, it must still be decided at what time (or over what period) cost is to be determined. Are prices to be limited by the current month's costs, by last year's costs, or by "standard "costs? And if the last, how shall we standardize the determination of standard costs?

Since the foregoing was set in type, the National Association of Cost Accountants has pronounced officially on the subject. It proposes that it be deemed unfair competition to sell at "less than the fair and reasonable cost, as determined on the basis of a system of cost accounting to be formulated by the Code Authority." Cost is defined as including "factory burden distributed on a basis of utilization of plant facilities for the industry as recommended by the Code Authority" (apparently the

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Muir plan). Sales below cost may be made, however, "to meet the prices of competitors who do not violate the code." In other words, the *low* cost of production is to govern. "Exceptions may be provided for particular industries, to govern seconds, dropped lines, etc." In these respects, the association leaves the subject as it found it. It is interesting to note that the association's recommendation "does not imply any opinion as to the practicability or the impracticability . . . . . to accomplish either minimum selling prices or cost reduction." The inclusion of full overhead in all cases as a part of cost is clearly deemed impracticable.

ATTITUDE OF NRA CODES

Turning now to the attitude of the codes, not all of them deal with the matter. The motor-industry code, for example, is silent on the subject. Others dispose of it very simply, by a flat prohibition. Typical of this group of codes is that of the corset and brassiere industry, approved August 14; but flat prohibitions are rare. What are actually found are three clear-cut tendencies; the first, to avoid or postpone any definite stipulation; the second, to make exceptions to a strict prohibition; the third, in favor of the boldest kind of price fixing. Thus, the code for the lumber industry, approved August 19, sets up an authority empowered to establish minimum prices. Again, the banking code requires that banks within any district must adhere to the same maximum rate of interest. The soft-coal code, in effect October 2, forbids selling below a fair market price. Such market price is established regionally by associations of producers, subject to review by the Government. This is actual price fixing under Government supervision. The code treats the producer group as a monopoly, depending upon Government officials to protect consumers. It may be remarked that even monopolies are not always all-powerful with respect to prices. They cannot control the price-demand curve, nor can they prevent substitution.

The steel code provides that prices be filed with the national trade association. Such filed prices must then be adhered to. The stipulation that NRA regulation must not promote monopoly here became an issue in connection with the proposal for the loan of Government funds to buy steel rails. The United States Steel Corporation named a price of $37.75. This price having been publicly filed, the other three manufacturers of steel rails adhered to it. The Federal Coordinator of Transportation objected to this as collusive and unreasonable. Virtually, he was objecting not to a fixed price, but to a price which in his opinion was unreasonably high.

The move away from cut prices and toward price fixing is a move for correction of an old evil. To illustrate: The rules submitted to the Federal Trade Commission in the late summer of 1929 by manufacturers and wholesalers of plumbing and heating supplies contained the following:

Rule 14—Anti-Dumping. Shipping considerable quantities of surplus stock of plumbing and heating products into territories outside sellers' particular markets, and selling such stock at prices below existing prices in such territories, or the prices prevailing in their own territories, is an unfair trade practise.

Far more important, as a matter of code draftsmanship, is a very general recognition that it may be unwise or impracticable to forbid selling below cost (yours or mine or anybody's), excepting with reservations. The code for the hosiery industry, approved August 27, qualifies the prohibition by excepting "irregulars and seconds." The fishing-tackle manufacturers' code of August 19 provides that goods which must be converted into cash may be sold at any price not lower than the direct cost of labor and materials. This limitation is exceedingly important in the discussion which follows.

The code of the electrical manufacturers' industry, approved August 4, stipulates: "Dropped lines, seconds, or inventories which must be converted into cash to meet emergency needs" may be sold at such cut prices as the supervisory agency may approve.

The limiting stipulation of the fishing-tackle code reappears in principle in the retail code of October 23. Here it is provided that retailers may not sell at less than invoice cost, plus an (approved) allowance for actual wages of store labor. There are other exceptions to the absolute rule in this code, which do not call for discussion here.

The basic rule that sales must not be made below cost, and, still more, the exceptions to that rule, seem to require positively the adoption of uniform accounting methods and standards. This alone is an enormous value for which the NRA may take credit. It speeds up the movement toward uniform cost keeping, certainly by several years.

The exceptions to the basic rule which have been cited reflect a very general idea that selling below cost, as the term is generally understood (prior average unit cost), can scarcely be completely forbidden. Exceptions are necessary. Arthur Andersen, C.P.A., speaking before the American Trade Association Executives Convention, September 13, goes so far as to deny that it is "possible to accurately determine the overall cost of a product," and asserts that if the prohibition of selling below cost refers to this overall cost, it is a "mandate which is impractical of application." "Every business man," he says, "knows that there are times when the life of the company depends upon going ahead in spite of a temporary loss." Such prohibitions "would have the effect of making it illegal to operate at a loss."

Administrator Muir, already quoted, deals with this subject. "In some cases even full 'out of pocket' costs would put the price of a product so high that sales would be killed." In other words, the prohibition does not refer to total costs. "In cases . . . it would be unfair to the industry for the code authority to say that it must figure in its cost full overhead." (Cases where operation is at a low percentage of capacity.) Proceeding to detail, Mr. Muir suggests "that the distribution of . . . indirect expenses per unit of product produced should be on the basis of an average rate of utilization of plant facilities by efficient producers dur-

ing the period 1927–32." And he goes on to formulate a method for determining such average rates.

CLASS PRICING

It is not yet clear whether exceptions to the rule of price not below cost are to go so far as to tolerate, and perhaps even to invite, "class pricing." This is an important issue.

Class pricing occurs when identical items or units of production are sold to different buyers or groups of buyers at different prices *not corresponding with differences in unit cost*. The sale of "seconds" at cut prices is not class pricing. The sale at cut prices of standard goods, not subject to depreciation in storage, "which must be converted into cash," is class pricing.

Class pricing is more general than is always realized. Some confusion exists because of a very general association of class pricing with quality differentials. A large part of our export trade, at least in those items in connection with which an import duty is levied, is sold on a class-price basis. The foreigner pays less than the domestic buyer. Opponents call this "dumping." Selling the same article under different brands at different prices is class pricing. Special sales, even those in which no telephone or mail orders are accepted, and with which C.O.D. and exchange privileges are suspended, involve class pricing. Monopoly products are frequently class-priced, although some power-company managers will indignantly deny that price differentials recognize anything more than the cost differentials. Our railroad freight-rate structure is an outstanding example of class pricing. A large part of the trouble with our agricultural situation arises from the failure of class pricing where there are millions of producers. Thus, with a tariff on wheat, the domestic price of wheat should be higher than the world price by the amount of the tariff. But the number of producers is so great that they compete with one another for the preferential home market, and this competition brings down the domestic price. Many of the farm relief measures proposed, including the export debenture, the equalization plan, etc., essentially aimed at the establishment of effective class pricing for farm products.

The practise of class pricing is particularly feasible where production is diverse; that is, where the manufacturer is turning out not a single uniform staple product, but a variety of articles. Class pricing then exists whenever any item of production is required to bear less than its full quota of overhead cost.

The manufacturer's argument for class pricing is based on the conception of constant overhead. (It would be better, perhaps, to speak of constant total costs—costs that for the whole period under consideration are uniform from sub-period to sub-period, regardless of variations in output.)

CLASS PRICING TO AVOID LOSSES

Suppose manufacturing capacity to be 100,000 barrels per day, month, or year; and the constant cost ("overhead") to be $100,000 for the same period; and direct cost to be $1 per barrel. The total unit cost is then $2 per barrel. The selling price might be set at $2.25. But suppose the manufacturer found that at this selling price he could sell only 60,000 barrels. At such volume of output his unit cost would be $2.67 per barrel. Unless he elects to sell at a loss he must shut down. But now suppose that in addition to 60,000 barrels at $2.25, he can sell 40,000 barrels at $2 per barrel: he may then operate at full capacity with a total revenue of $215,000 against costs of $200,000. The margin may not be very generous, but it is a margin.

Note that he is selling part of his product at $2. He could not sell it all at that price because that would allow no margin of profit. By selling part of the output at "less than cost" he makes a profit.

If the buyers who are paying $2.25 denounce this as unfair, the obvious rejoinder is that unless the 40,000 barrels are sold at $2, those buyers who would take 60,000 barrels must either pay $2.67 or go without. The allegedly unfair practise saves them 42 cents per barrel.

It is a hard principle to accept, for it involves the seller's making sales at $2 at a moment when his then actual average cost is $2.67; but, if the arithmetic is correct, this kind of selling below cost benefits the manufacturer, the wage earner, and the buyer. It gives the manufacturer a profit which he would otherwise not receive. It gives employment to wage earners which they would otherwise not have. It gives some buyers a lower price than would otherwise be possible; and it gives other buyers the enjoyment of goods which they could not otherwise possess. Broadly, this sort of selling below cost increases the quantity of goods enjoyed and seems, therefore, to be socially advantageous. It is practicable only where there is, or may readily be, excess capacity.

There is an obvious rejoinder; and many indignantly condemn the policy outlined as academic and fallacious. The difficult question is: Who shall be the favored group? And how can the separation of buyers into groups be brought about? The examples of class pricing which have been given show the bases of some such separations. Probably all of us are familiar with the fact that standard goods are sometimes sold at different prices in different districts of a city. It is not the purpose of this present discussion to invent ways and means for a further extension of class pricing. It is remarked, however, that the practise has something in common with still more wide-spread policies. At least some of our taxes are levied on the principle of what the traffic will bear, rather than on the basis of the cost of the various community services. Such taxation is class pricing.

Class pricing should properly not involve regional dumping, except, perhaps (in our present nationalistic economy), in international trade. The objection to regional dumping is that it implies reduced overall efficiency because it leads to excessive transportation and selling costs.

The principle under discussion is that a manufacturer

(*Continued on page 157*)

HEAT-TRANSFER RATES

Discussion of the Data Fundamental to the Practise of Heating, Ventilating, and Air Conditioning

By F. C. HOUGHTEN[1]

ALTHOUGH the broadening scope of heating and ventilating, including air conditioning, involves the consideration of many factors, such as air purity, moisture content, and freedom from dust, odors, and bacteria, thermal engineering still remains the dominant factor. In establishing conditions of human comfort, the air-conditioning engineer is interested in the economical transfer of heat from the heating medium to the atmosphere of the building. He is also interested in retarding the rate of dissipation of heat from such occupied areas through the walls to the outside atmosphere. Conversely, with cooling in summer, he is interested in the economical transfer of heat from a building and through the cooling equipment to the outside, and the heat flow into the building through the walls. Even the processes of humidification and dehumidification involve the transfer of heat. Thus, heating and ventilation, or air conditioning, involve almost every mode, and a wide variation of rates, of heat transfer.

Unlike the engineer interested in thermal problems in industrial processes, the engineer interested in air conditioning is confronted not only with the need for the economic control of heat, but he is also faced with the fundamental requirement that the application is for the purpose of making people comfortable and satisfied. While an engineer may design, build, and install a heating system which is perfect in so far as thermal-engineering requirements are concerned, it will be an economic loss if the occupant is not pleased with the comfort it provides, the appearance of the heaters and their location, the noise, including even the faintest sound emanating from the system, and any other factor which may please or displease him. This human factor confronts every air-conditioning engineer and often limits him in obtaining what might otherwise be economical transfer and utilization of heat.

Again, the engineer interested in the air conditioning of homes is frequently confronted with the requirement of low first cost, and hence inefficient heat transfer and utilization, even though a sound engineering analysis of first cost, cost of operation, and cost of maintenance indicate the economy of a more efficient system with a resulting higher initial cost. These facts frequently dictate rates and efficiencies in the generation, transfer, control, and utilization of heat in air conditioning and are not generally understood by the thermal engineer not connected with this branch of the profession.

HEAT TRANSFER WITHIN THE GENERATING UNIT

While the generation and transfer of heat in the heating boilers and furnaces of small buildings are similar to like processes in power-plant practise, the rates and efficiencies of transfer and utilization may differ widely because of limitations imposed by the purchaser and the lack of expert attention.

Heat-generating units used in buildings vary widely according to the fuel or source of heat used and the system of distributing the heat throughout the building. They may be classified as boilers for steam and hot-water heating and furnaces for warm-air heating systems.

The heat-transfer rates per unit area of surface in heating boilers vary widely, depending upon the type and make of boiler, the fuel used, the percentage of capacity at which the boiler is operating, and the location of the surface in the boiler. The total heating surface of boilers using solid fuel is made up of the heating surface in contact with the fuel bed, the surface above the fuel bed but in view of it, and the surface over which the hot gases of combustion pass.

The amount of heating surface in direct contact with the fuel bed varies widely with designs and sizes of boilers, and the percentage of surface in direct contact with the fuel bed is generally greater in small round boilers than in large rectangular boilers.

Perhaps the best data available on heat transfer through a surface in contact with the fuel bed are contained in a United States Bureau of Mines publication,[2] which gives operation characteristics and rates of heat transfer for the parts of a small round boiler. Heat-transfer rates ranging from 1710 Btu per sq ft of heating surface per hour when burning bituminous coal at a rate of 1.3 lb per sq ft of grate per hour, to 6580 Btu per sq ft per hr with a combustion rate of 4.4 lb per sq ft per hr are given. Anthracite gave heat-transfer rates ranging from 2630 to 10,130 Btu per sq ft per hr for combustion rates ranging from 1.4 to 5.2 lb per sq ft of grate per hour. For coke, heat transfer rates ranging from 3160 to 11,450 Btu per sq ft per hr were found for combustion rates ranging from 1.5 to 5.6 lb per hr.

Heat-transfer rates for surfaces in contact with hot gases are seldom given for unit areas of surface for any particular part of the boiler, principally because such values cannot easily be determined by experiment, and because the many variations in shape and location of such surfaces met with in practise, particularly in cast-iron boilers, do not lend themselves to the determination of unit rates by calculation. It is customary to express the rate of heat transfer as an average for all the heating surface in the boiler. The United States Bureau of Mines[3,4] gives such average rates of heat transfer for boilers operating under different conditions and burning different kinds of solid

[1] Director, Research Laboratory, American Society of Heating and Ventilating Engineers, Pittsburgh, Pa. Mem. A.S.M.E.

Presented at a session on heat transfer, under the joint auspices of the American Society of Heating and Ventilating Engineers, the American Society of Refrigerating Engineers, and the A.S.M.E. Process Committee, at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] "Heat Transference and Combustion Tests in Small Domestic Boilers," by John Blizard, W. M. Myler, Jr., J. K. Seabright, and C. P. Yagloglou, Trans. Am. Soc. Heat. & Vent. Engrs., vol. 29 (1923), p. 253.

[3] "Value of Coke, Anthracite, and Bituminous Coal for Generating Steam in a Low-Pressure Cast-Iron Boiler," by John Blizard, James Neil, and F. C. Houghten, United States Bureau of Mines Technical Paper No. 303, September, 1922.

[4] "Value of Bituminous Coal and Coke for Generating Steam in a Low-Pressure Cast-Iron Boiler," by C. E. Augustine, James Neil, and William M. Myler, Jr., United States Bureau of Mines Technical Paper No. 367, 1925.

TABLE 1 RATES OF HEAT TRANSFER, BURNING BITUMINOUS AND ANTHRACITE COAL AT DIFFERENT RATES OF COMBUSTION

	Cast-Iron Vertical Sectional Boiler —Mfr's Rating, 10,900 Sq Ft Radiation—						Cast-Iron Vertical Sectional Boiler —Mfr's Rating, 15,600 Sq Ft Radiation—								
	Bituminous			Coke			Coke			Anthracite			Bituminous		
Draft in smoke hood, in. H_2O	0.18	0.62	1.29	0.14	0.69	1.33	0.116	0.262	0.720	0.154	0.530	0.900	0.200	0.382	0.850
Per cent of mfr's rating	47	99	139	51	96	127	50	80	113	54	89	102	56	85	117
Smoke hood temp, F	512	758	832	426	673	757	347	447	554	368	537	529	557	761	654
Heat transfer rate Btu/sq ft/hr; Average for all heating surface	3437	7212	10114	3737	6967	9234	2310	3710	5240	2520	2685	4134	2610	3760	5436
Heat release, Btu/hr/cu ft	31800	68300	98900	28950	62100	83700	16500	27600	39000	18700	20400	34300	14800	33400	43400

fuel. Table 1 gives average rates of heat transfer found for two boilers burning anthracite, coke, and bituminous coal at different rates of combustion.

It should be emphasized that these heat-transfer rates are averages for the entire boiler and are made up of varying rates ranging from a maximum where the hot gases leave the point of combustion at temperatures which may reach as high as 1800 F to minimum rates of heat flow at points where the flue gases leave the boiler at temperatures which may be as low as 300 or 400 F.

Table 2, taken from the "Guide"[5] of the American Society of Heating and Ventilating Engineers, gives ranges in rates of heat transfer for different operating conditions met with in heating practise.

TABLE 2 PRACTICAL AVERAGE RATES OF HEAT TRANSFER FOR BOILERS EXPRESSED IN BTU PER SQ FT PER HR, BASED ON AVERAGE OF ALL HEATING SURFACE IN THE BOILER

Type of Equipment	Load	Efficiency (Per cent)	Small Boilers (Below 100 sq ft boiler heating surface)	Medium to Large Boilers (Above 100 sq ft boiler heating surface)
Solid fuel, stoker or hand fired	Design[a]	65–75	2000–2500	3000–3500
	Design	55–65	2500–3000	3500–4000
	Maximum[b]	50–60	3500–4500	4500–6000
Oil-burning boilers, intermittent operation with full automatic control	Maximum	75	2500–3000	3000–4000
	Maximum	65	3000–4000	4000–5000
Oil-burning boilers, high and low fire, automatic or manual control	Design	75	2500–3000	3000–4000
	Maximum	65	3500–4500	4500–6000
Gas-burning boilers,[c] intermittent operation with full automatic control	Maximum	70	3000–3500	3500–4500
Gas-burning boilers, high and low fire, automatic or manual control	Design	75	2500–3000	3000–4000
	Maximum	65	3500–4000	4000–5000

[a] Design load consists of connected load, including piping, plus domestic water-heating load.
[b] Maximum load includes design load plus heating-up allowance.
[c] Principally applicable to conversion boilers with smooth flue passages. Gas-designed boilers usually have extended surface, to which these data do not apply.

The heat-transfer rates per unit area of surface in warm-air heating furnaces also vary widely, depending upon the type and make of furnace, the fuel used, the percentage of capacity at which the furnace is operated, and the location of the surface within the furnace. Few or no data are available giving the unit-area transfer rates for various parts of the heating surface. It is the practise in the furnace industry to give combustion rates for various types of fuel in pounds per square foot of grate area and the ratio of heating surface to grate area. From these values, the calorific value of the fuel and the thermal efficiency of conversion from fuel to heat in the furnace bonnet, average rates of heat transfer for the entire heating surface area in the furnace may be computed. Very comprehensive studies of these and other relationships in warm-air heating-furnace practise have been carried on by Prof. A. C. Willard,[6] of the University of Illinois, whose studies show that in good furnace practise ratios of heating surface to grate area may range from 17 to 27, and heating efficiencies may range from 48 to 70 per cent. Accepting values of 4 lb of 12,500-Btu coal per hour per square foot of grate area as the combustion rate, 27 as the ratio of heating surface to grate area, and 68 per cent as the heating efficiency as representing practical operating conditions for a moderately low rate of heat transfer, the average for all heating surfaces in the furnace is 1259 Btu per sq ft per hr. Accepting for a moderately high average rate of heat transfer a combustion rate of 11 lb of 12,500-Btu coal per hour per square foot of grate area, a ratio of heating surface to grate area of 17, and a heating efficiency of 50 per cent, gives an average heat-transfer rate of 4044 Btu per sq ft per hr. The former may be taken to represent an efficient furnace with a large area of heating surface operating at a low rate; the latter to represent a less efficient furnace with less heating surface and operating at a relatively high rate. Again, it should be emphasized that these average rates of transfer are obtained by variations ranging from very much higher rates near the point of combustion to very much lower rates near the point at which the flue gases leave the furnace.

The rates of heat release in a furnace are only indirectly connected with the rates of heat transfer to the air or water. Their numerical values have little meaning unless associated with the fuel being used, the design of the furnace as related to the mixing of the gases, and the basis on which the normal rating is

[5] "Guide" (1933 edition), Am. Soc. Heat. & Vent. Engrs., chap. 14, p. 205.

[6] "Mechanical Equipment of Buildings," by Harding and Willard, second edition, vol. 1, chap. 16.

fixed. Consequently, the nominal heat release per cubic foot computed for different makes and sizes of boilers varies widely. This is illustrated by the values for heat release given for the two boilers of Table 1.

The rates of heat release for five small boilers based on the manufacturers' ratings at the time the tests were made are illustrated by the following:

Manufacturer's rating, radiation in sq ft	540	575	600	650	680
Nominal heat release, Btu per hr per cu ft	36,000	39,000	22,000	60,000	32,000

Thus, a heat release of 35,000 Btu would seem to be an average figure. The volume of the combustion space of warm-air furnaces is usually larger than that for boilers, and the nominal heat release will be correspondingly less.

In the application of oil firing or of stokers to standard boilers, it has been customary to increase the combustion space. A committee has been appointed by the American Standards Association to standardize the settings of stokers and the combustion space necessary to produce good combustion with reasonable production of smoke.

HEATING UNITS

Steam and hot-water heating units are divided according to use into the following classifications:

(*a*) Radiators, sometimes called "direct" radiators, are located within the room or space to be heated and exposed to view; hence, they give off heat by radiation and convection.

(*b*) Concealed heaters for gravity air circulation, more commonly called "convectors," are located either within or adjacent to the room or space to be heated but concealed from view by an enclosure or cabinet with means for air entrance and exit. Little or no heat is given off by radiation but much by convection currents passing through the enclosure. Many combinations of classifications (*a*) and (*b*) are found in practise.

(*c*) Heating units for mechanical air circulation are used in any system where air is blown through the unit, as in steam or hot-water central fan systems, unit heaters, and unit ventilators. Similar cooling units are used in cooling practise. The same unit may be used for both heating or cooling.

Either radiators or convectors may have only direct surface, that is, surface backed by hot water or steam on the inside; or both direct and extended surface, the latter being heating surface not backed by steam or hot water. Direct surface in a radiator may be so located as to give off heat by both radiation and convection; or, it may be so placed as to give off heat by convection only. These variations, affecting as they do the rate of heat transfer, make it difficult to give generalized values for rates of heat transfer met with in practise.

The highest rate of transfer per unit area of surface is met with when using surfaces in full view of objects within the room or space to be heated, so that both radiation and convection are fully effective as modes of heat emission from all the surface. For such surfaces there is further variation in the rate of heat emission due to the shape and location of the surface. These variations may greatly affect the velocity and temperature of convection currents over the surface but not the radiation. The characteristics of the surface affecting its emissivity also affect the rate of transfer.

The Research Laboratory of the American Society of Heating and Ventilating Engineers has found[7] values of 412, 394, 381, and 342 Btu per sq ft of surface per hour for $^3/_4$-in., 1-in., $1^1/_4$-in., and 4-in. horizontal black iron pipe, respectively, for steam at 215 F and an air temperature of 70 F. Ten-foot lengths of pipe in the vertical position showed a slightly lower rate of transfer, and a commercial four-ply, air-cell, pipe covering reduced these rates of transfer to 131, 115, and 102, respectively, for the three smaller sizes of black iron pipe. Horizontal copper pipe, $^3/_4$ in., 1 in., $1^1/_4$ in., and 4 in. in outside diameter, bare and with a bright (as received, not polished) surface, gave rates of emission of 291, 277, 255, and 191 Btu per sq ft of surface per hour, respectively, with steam at 215 F and an air temperature of 70 F.

Heilman[8] gives values of heat emission for bare black iron pipe ranging from 425 Btu per sq ft per hr for $^1/_2$-in. pipe to 319 for 18-in. pipe, which indicates, by extrapolation, a value of approximately 313 Btu for an infinite diameter or a flat surface.

Radiator surfaces exposed fully to view may therefore give rates of heat transfer ranging from 313 to 425 Btu per sq ft per hr, depending upon the shape and location of the surface. However, since radiators are usually designed so as to give a greater amount of convection surface than radiating surface, the rate of heat transfer per unit of surface area varies downward from these maximum values. For cast-iron radiators of the usual column and tube design and with steam at 215 F and room temperature at 70 F, the average rate of heat transfer per square foot of surface per hour gives averages of approximately 240 Btu. Table 3 gives rates of transfer for several

TABLE 3 HEAT-TRANSFER RATES FOR SEVERAL TYPES OF COMMERCIAL RADIATORS

Type of Radiator	Height in Inches			
	20	23	26	38
1 Column[a]	276	279	270	256
2 Column[a]	263	261	256	242
3 Column[a]	252	242	234	228
4 Column[a]	247	236	229	210
Hospital[a]	281	277	273	257
Wall[a]	...	295	...	...
Window[a]	224	...	...	...
Tubular, 5 tube[b]	...	...	...	255.2
Commercial pipe coil[b]	307.4	...	...	...

[a] "Direct Radiation Tables," by F. Paul Anderson, F. C. Houghton, and Louis Ebin, *Journal*, Am. Soc. Heat. & Vent. Engrs., December, 1921, pp. 847–853.

[b] "Mechanical Equipment of Building," by Harding and Willard, second edition, vol. 1, p. 284.

recognized commercial types of radiators found in use as given by the Research Laboratory[9] and by Harding and Willard.[10]

Until recently, radiators were rated according to actual surface area. However, since there is little correlation between the surface area and heat emission, this practise has been discontinued, and such radiators are now rated in equivalent square feet of heating surface. A square foot of heating surface is defined as a rate of emission of 240 Btu per hour.

Concealed heating units or convectors are designed to give off little or no heat by direct radiation, and as a result, the ratio of the total heat-emitting surface to the surface emitting

[7] "Heat Emission From Iron and Copper Pipe," by F. C. Houghten and Carl Gutberlet, *Heating, Piping, and Air Conditioning*, January, 1932, p. 47.

[8] "Heat Transmission From Bare and Insulated Pipe," by R. H. Heilman, *Industrial and Engineering Chemistry*, May, 1924, vol. 16, no. 5, p. 451.

[9] "Direct Radiation Tables," by F. Paul Anderson, F. C. Houghten, and Louis Ebin, *Journal*, Am. Soc. Heat. & Vent. Engrs., December, 1921, pp. 847–853.

[10] "Mechanical Equipment of Buildings," by Harding and Willard, second edition, vol. 1, p. 284.

heat by radiation may become considerably higher than is the case with radiators. Many convectors are designed with a large percentage of extended surface. Obviously, for heaters with large percentages of surface concealed from view and heaters with large percentages of extended surface, the rate of heat transfer expressed in Btu per unit of actual surface area becomes much less than the maximum value indicated for direct radiators. In fact, an expression of heat-transfer rate per unit of area for such heaters would have little value in practise. The main factors affecting the design of either radiators or convectors today are not the rates of heat transfer but the appearance of the unit, the space occupied by it for a given total heat emission, and the location, direction, velocity, and temperature with which the currents of heated air enter the room.

Steam or hot-water heating is frequently accomplished by blowing air over a heating surface instead of depending upon radiation and natural convection currents. The rate of heat transfer per unit area of surface of this type of surface varies widely, depending upon the degree to which the air scrubs over the heating surface, whether or not the heating surface is direct or extended, and the distance along the direction of air flow over which the heating surface extends. Pipe coils and, later, cast-iron units were largely used prior to the prevalence of non-ferrous types of heaters that have been used during the past few years.

Pipe coils and cast-iron heating units are rather regular in shape, and it has been customary to give the rate of heat emission for different operating conditions in Btu per hour per square foot of surface. With the greater use of extended surface and smaller non-ferrous tubes and other irregular shapes and spacing, less consideration has been given to surface area and more to the possible rates of heat transfer for unit space, cross-sectional area, frictional resistance to the flow of air through the heater, weight, durability, and cost. Table 4 gives heat-transfer rates for three types of heaters and different operating conditions, as given by Allen,[11] Soule,[12] and Bousquet.[13]

TABLE 4 HEAT-TRANSFER RATES FOR MECHANICAL AIR CIRCULATION HEATING UNITS FOR VARIOUS AIR VELOCITIES

	1-In. Pipe Coil on $2^3/_4$-In. Centers, 25 Rows High[a]			Five Sections 60-In.		Air Tube Cellular Type Copper Heater[c]		
Characteristics of Heater	20 rows deep		4 rows deep	Cast iron[b]		6-in. tube		$3^7/_8$-in. tube
Air velocity	542	1196	1189	670	1430	850	2460	908
Air temp rise, deg F	91.5	73.6	16.7	104.6	82.2	68.6	61.3	42.3
Mean air temp, deg F	95.2	75.6	55.0	75.9	63.3	72.9	85.9	110.8
Frictional resistance	0.120	0.540	0.108	0.095	0.440	0.081	0.590	0.086
Transfer rate, Btu per hr per sq ft	948	1690	1910	994	1654	760	2120	778

[a] John R. Allen, Transactions, Am. Soc. Heat & Vent. Engrs., vol. 23 (1917), p. 141.
[b] L. C. Soule, *Ibid.*, vol. 19 (1913), p. 391.
[c] L'Rouche, G. Bousquet, and G. A. Foisey, *Ibid.*, vol. 31 (1925), p. 161.

HEAT-TRANSFER RATES THROUGH COMMON TYPES OF BUILDING CONSTRUCTION

The type of building construction used in outside walls is of utmost importance in the heating and ventilating or air conditioning of a building, since a large part of the heating load, and therefore the cost of heating, is to take care of the heat loss through such walls. In the case of summer cooling, wall construction is of even greater importance, since the cost of removing a given quantity of heat for summer cooling is greater than the cost of generating and supplying the same quantity of heat for winter heating.

The rates of heat transfer met with in practise in building construction necessarily vary as widely as the type of construction and the severity of the outside weather. The greatest rate of heat transfer met with in building construction is that which takes place through windows. Glass in itself has very high conductivity, and the rate of transfer through a single thickness of glass window is largely determined by the inside and outside film-conductance coefficients. The film-conductance coefficient for glass as determined by Professor Rowley,[14] of the University of Minnesota, in cooperation with the Research Laboratory of the American Society of Heating and Ventilating Engineers, is 1.55 Btu per sq ft per hr per deg of temperature difference between the glass and air for still air, or natural convection currents resulting from the prevailing differences in temperature. This surface coefficient increases rapidly with wind velocity, reaching approximately 5.25 Btu per sq ft per hr per deg of temperature difference with a 15-mile wind. The Research Laboratory[15] expresses this relationship approximately as $f_0 = 1.4 + 0.281V$, where f_0 is the rate of heat transfer in Btu per hr per sq ft per deg of temperature difference between the surface and the air for a wind velocity of V miles per hour. Accepting these surface transfer coefficients and ignoring the resistance to flow offered by the material of the glass itself, the rate of heat transfer through a single thickness of window glass with a temperature of 70 F inside, zero outside, and a 15-mile wind is 78.5 Btu per sq ft per hr.

Better building practise now dictates that where severe conditions are met with, either storm sash or double glazing shall be used. With two thicknesses of glass the above rates of heat transfer for zero outside and 70 F inside become 31.5 per sq ft per hr, with a 15-mile wind. With triple glass the rate is reduced to 19.6 Btu per sq ft per hr.

The rates of heat transfer through walls of buildings vary widely according to the type of construction. For example, a nominal 4-in. studding with plaster board and stucco on the outside and metal lath and plaster on the inside, and with an outside wind velocity of 15 miles per hour, gives a rate of transfer of 0.43 Btu per hr per sq ft of wall per deg of temperature difference between the air inside and the air outside.

[11] "Comparison of Pipe Coils and Cast-Iron Sections for Warming Air," by John R. Allen, Transactions, Am. Soc. Heat. & Vent. Engrs., vol. 23 (1917), p. 141.

[12] "Heat Transmission With Pipe Coils and Cast-Iron Heaters Under Fan-Blast Conditions," by L. C. Soule, *Ibid.*, vol. 19 (1913), p. 391.

[13] "Characteristics of an Air-Tube Type Copper Heater," by L'Rouche, G. Bousquet, and George A. Foisy, *Ibid.*, vol. 31 (1925), p. 161.

[14] "Surface Conductances as Affected by Air Velocity, Temperature, and Character of Surface," by F. B. Rowley, A. B. Algren, and J. L. Blackshaw, Transactions, Am. Soc. Heat. & Vent. Engrs., vol. 36 (1930), p. 434.

[15] "Wind Velocity Gradients Near a Surface and Their Effect on Film Conductance," by F. C. Houghten and Paul McDermott, *Heating, Piping, and Air Conditioning*, March, 1931, p. 229.

With a temperature of 70 F inside and 20 F outside and with a 15-mile wind, the actual rate of heat transfer for this type of construction becomes 21.5 Btu per hr per sq ft of wall. If the outside temperature drops to —20 F and other conditions remain the same, the rate of heat transfer increases to 38.7 Btu per hr per sq ft of wall. It should be emphasized that this construction is of the poorest type and is not frequently met with in practise. Other types of construction met with are: 8-in. solid brick with $^1/_2$-in. plaster on the inside, giving a unit transfer coefficient of 0.46 Btu per hr per sq ft per deg F of temperature difference; 8-in. hollow tile with $^1/_2$-in. plaster on the inside, giving 0.37 Btu; 6-in. concrete wall, giving 0.79; 4-in. brick veneer on 6-in. solid concrete, giving 0.57 Btu; all with a 15-mile wind. Filling the studding space of the stucco-plaster wall with rockwool insulation reduces the coefficient from 0.43 to 0.073 Btu per hr per sq ft per deg o temperature difference. With an inside temperature of 70 F and an outside temperature of zero and a 15-mile wind, the addition of the insulation reduces the actual rate of heat transfer from 30.1 to 5.11 Btu per hr per sq ft.

A rather standard type of frame-house construction consists of wood siding or clapboards, building paper, 1-in. wood sheathing, 4-in. studding, lath, and plaster. This gives a unit transfer coefficient of 0.26 Btu per hr per sq ft per deg F of temperature difference; and with 70 F inside and zero and a 15-mile wind outside, 18.2 Btu per hr per sq ft will flow out. A wall composed of 8-in. brick with furring, lath, and plaster, which also may be considered as standard house construction, gives a unit coefficient of 0.30 Btu per hr per sq ft per deg F of temperature difference.

Very good house construction may be represented by a wall consisting of wood siding, building paper, 1-in. sheathing, 4-in. studding space, and $1^1/_2$-in. corkboard and plaster, giving a unit coefficient of 0.11 Btu per hr per sq ft per deg F of temperature difference (or the same wall with a rockwool insulation in the studding space, wood lath, and plaster) gives a coefficient of 0.066 Btu. Brick constructions having similar rates of heat transfer may be represented by 8-in. solid brick, 2-in. corkboard insulation, and plaster, giving a unit coefficient of 0.11 Btu, or actual rates of transfer, with 70 F inside and 20 F, zero, and —20 F outside with a 15-mile wind, of 5.5, 7.7, and 9.9 Btu per hr per sq ft of wall.

Tabulation of unit heat-transfer coefficients for many types of building construction met with in practise may be found in the "Guide" of the American Society of Heating and Ventilating Engineers, resulting largely from research carried on by the Society's Research Laboratory at Pittsburgh, and by Professor Rowley at the University of Minnesota in cooperation with the Research Laboratory.

EFFECT OF HEAT CAPACITY OF THE BUILDING STRUCTURE ON INSTANTANEOUS RATE OF HEAT TRANSFER

While a great many tests have been made to determine the rate of heat transfer through different types of building construction under conditions of equilibrium, that is, with constant-temperature gradients through the structure, it has been demonstrated by laboratory studies[16] that the results of these tests, while valuable, fall far short of giving a complete picture of the actual rates of heat transfer into or out of a building under natural weather conditions. During the winter season the occupied portion of a building must be heated to approximately 70 F, with a daily cyclic temperature change on the outside frequently varying by 20 deg between day and night.

Under such conditions and with fairly heavy types of masonry construction, the effect of the low temperature at night may result in maximum rate of heat transfer from the inside of the room to the inside surface of the wall as much as nine hours later, with a similarly delayed minimum. This cyclic flow results not only in a delayed rate of heat transfer from the heated portion of a building but also in a greatly decreased maximum rate of heat loss, because the fact that the maximum temperature difference due to the diurnal cycle is never of sufficient duration to result in a corresponding rate of heat transfer from the inside of the room to the inside surface of the wall.

Similarly, extremely cold spells being of relatively short duration followed by rising temperatures seldom result in rates of heat transfer from the inside of the building equal to that found by test or calculated from test results and based upon a constant temperature difference of the same magnitude over a sufficient length of time to establish equilibrium of flow.

COMPLICATIONS ARISING FROM THE EFFECTS OF HEAT FROM SOLAR RADIATION

The effect of solar radiation in complicating the question of determining the actual rates of heat transfer from buildings during the heating season and into buildings cooled during the summer is of great importance. This is particularly true in its effect on the cooling of buildings in the summer. The outside surface of a roof exposed to direct solar radiation may reach a temperature from 50 to 70 deg higher than the outside air temperature, resulting in extremely high rates of heat transfer. However, again since the solar effect is cyclic, reaching its maximum only during a short period of the day, this effect on the rate of heat transfer into the occupied and cooled space is frequently delayed a number of hours and accordingly diminished in magnitude. The effect of solar radiation on heat transfer through walls and roofs was studied by the Research Laboratory of the American Society of Heating and Ventilating Engineers.[17,18] There is still need for considerable study in order that the results of these effects may be accurately calculated in terms of actual rates of heat transfer into or out of buildings for any particular time.

Solar radiation reaches its maximum effect on the cooling of occupied space in the summer by direct solar radiation through windows. The intensity of solar radiation as shown by studies at the Research Laboratory[19] frequently reaches a value of 300 Btu per sq ft per hr, normal to the direction of radiation. Window glass as has been shown by studies by the Laboratory,[19] may decrease this intensity by from 10 to 15 per cent. Direct radiation of solar energy through glass is of great importance in summer cooling, as shown by a study of the cooling requirements of an office building by Walker.[20]

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[16] "Coefficients of Heat Transfer as Measured Under Natural Weather Conditions," by F. C. Houghten and C. G. F. Zobel, Transactions, Am. Soc. Heat. & Vent. Engrs., vol. 34 (1928), p. 397.

[17] "Heat Transfer Through a Roof Under Summer Conditions," by F. C. Houghten and C. G. F. Zobel, Transactions, Am. Soc. Heat. & Vent. Engrs., vol. 34 (1928), p. 413.

[18] "Heat Transmission as Influenced by Heat Capacity and Solar Radiation," by F. C. Houghten, J. L. Blackshaw, E. M. Pugh, and Paul McDermott, *Heating, Piping, and Air Conditioning*, April (1932), p. 288.

[19] "Absorption of Solar Radiation in Its Relation to the Temperature Color, Angle, and Other Characteristics of the Absorbing Surface," by F. C. Houghten and Carl Gutberlet, Transactions, Am. Soc. Heat. & Vent. Engrs., vol. 36 (1930), p. 137.

[20] "Field Studies of Office Building Cooling," by J. H. Walker, S. S. Sanford, and E. P. Wells, *Heating, Piping, and Air Conditioning*, February, 1932, p. 125.

WORKING STRESSES *for* HIGH-TEMPERATURE SERVICE

By P. G. McVETTY[1]

THE PROBLEM of the assignment of working stresses for high-temperature service depends primarily upon the interpretation of the results of high-temperature tests. A solution of this problem requires satisfactory service over a reasonable period of time at minimum cost. Progress in high-temperature design demands that any deficiency of data necessary to effect a solution must be met by a courageous interpretation of available information by the metallurgist, the testing engineer, and the designer. The present tendency to shift the whole burden of responsibility for interpretation of test data to the shoulders of the designer is unfair not only to him but also to the material which may be discarded solely as a result of improper interpretation or application.

So many factors affect choice of materials and assignment of working stresses that it is necessary carefully to define the limits of the present discussion. Of the various types of tests which have been used, attention is confined to the long-time tension or creep test for which the largest amount of reliable information has been obtained. This does not preclude the possibility of the displacement of this test by others in the future. For the present, complications introduced by consideration of changes in stress or temperature, by fatigue, impact, corrosion, or other service conditions must be left for later discussion. Applications are restricted to materials which maintain satisfactory ductility throughout their service life. The important question of stability as it may be affected by age hardening, annealing, or other internal changes is a strictly metallurgical problem which cannot be included in the present discussion. It is also necessary to exclude complicated cases such as highly stressed tubes at very high temperatures for which simple tension creep tests may not be a satisfactory basis for working stresses. Within the limits outlined, the assignment of a safe working stress for a ductile material depends upon a knowledge of the relations among the four variables—temperature, stress, deformation, and time.

TWO TYPES OF HIGH-TEMPERATURE DESIGN PROBLEMS

High-temperature design includes two distinct classes of problems dependent upon the aforementioned four variables, One may be represented by a bolt which holds two flanges together at high temperature. The original tightening of the nut applies an initial stress and corresponding initial elastic deformation to the bolt and the material surrounding it. As creep occurs, the total deformation remains essentially constant, while elastic strain is converted into plastic strain or creep with a corresponding decrease in stress. Eventually, leakage at the flange may be expected unless the bolts are retightened or the design is such that a suitable stress is maintained during the service life. This is commonly called the "relaxation problem," consideration of which will be reserved for a later paper.

In the other type of problem, stress and temperature are essentially constant while deformation or creep varies as a function of time. In the conventional long-time tension or creep test,[2,3,4] an attempt is made to simulate these conditions by maintaining constant stress and temperature, while the relations between time and deformation are studied. It is generally agreed that this type of test is the most satisfactory of those which have been commonly used up to the present time for supplying design information based on the relations among the four variables being considered.

PLAN OF ATTACK ON PROBLEM OF APPRAISING AND CORRELATING DATA IS PROPOSED

In order to appraise and correlate all existing test data so as to make them available in convenient form for design use, it is necessary to reduce them to comparable form with due allowance for the effect of uncontrolled variables. It is the main purpose of this paper to suggest a plan of attack upon this store of undigested information so as to obtain from it the greatest possible amount of use. It is realized fully that more or less arbitrary assumptions are necessary, but this may be preferable to the somewhat chaotic state of existing unrelated test data. Later checks will decide whether they were correct or must be altered.

Among the numerous papers on properties of metals at high temperatures, relatively little has been done to connect creep phenomena with known laws of physics and physical chemistry. Reference may be made to Dr. Nadai's discussions[5,6] of this phase of the problem because it appears evident that a satisfactory solution depends upon a more perfect understanding of the fundamental laws governing creep phenomena. Important work has been done[7,8] and experimental investigations now in progress are expected greatly to extend our knowledge in this field. The mention of creep tests under combined stresses indicates the extent of the field of investigation still to be explored before design can proceed with absolute assurance of success.

The following notation is used throughout this paper:

ϵ = total strain (unit elongation). $\epsilon = \epsilon' + \epsilon''$
ϵ' = elastic part of strain ϵ. $\epsilon' = \sigma/E$

[1] Westinghouse Research Laboratories, East Pittsburgh, Pa.
Presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of The American Society of Mechanical Engineers.

[2] "Creep of Metals at Elevated Temperatures," by P. G. McVetty, Mechanical Engineering, vol. 53 (1931), pp. 197–200.
[3] "Factors Affecting Choice of Working Stresses for High-Temperature Service," by P. G. McVetty, Trans. A.S.M.E., 1933, APM-55-13.
[4] "Obtaining Reliable Values for Creep of Metals at High Temperatures," by H. W. Gillett and H. C. Cross, *Metals and Alloys*, July, 1933.
[5] "The Creep of Metals," by A. Nadai, Trans. A.S.M.E., 1933, APM-55-10, pp. 61–77.
[6] A. Nadai, in a discussion of a paper entitled "Working Stresses," by C. R. Soderberg, Trans. A.S.M.E., 1933, APM-55-16, p. 141.
[7] "Creep of Steel Under Simple and Compound Stresses, and the Use of High Initial Temperature in the Steam Power Plant," by R. W. Bailey, Trans. Tokio, Japan, Sectional Meeting, World Power Conference, vol. 3 (1929), pp. 1089–1121. For abstract, see *Engineer*, vol. 148 (1929), pp. 528–9.
[8] "Strength of Materials Subject to Shear at High Temperatures," by F. L. Everett, Trans. A.S.M.E., 1931, APM-53-10, p. 117.

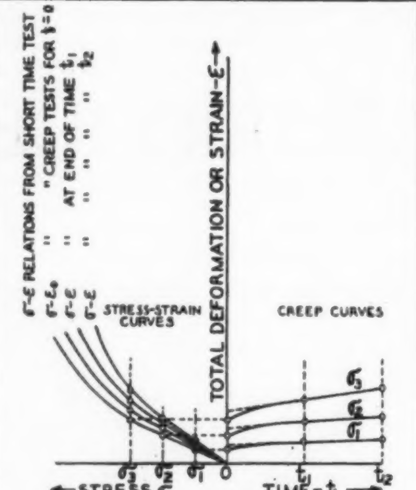

FIG. 1:-RELATION BETWEEN STRESS-STRAIN & CREEP CURVES AT CONSTANT TEMPERATURE

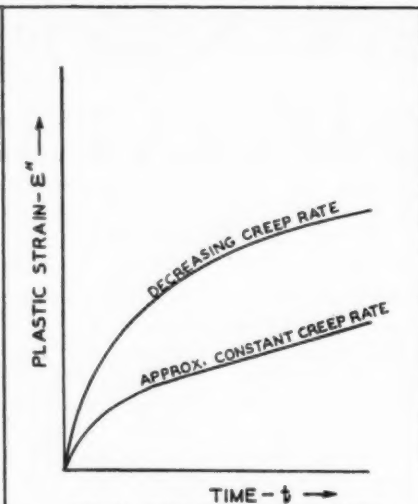

FIG. 2:-TWO TYPES OF CREEP CURVES

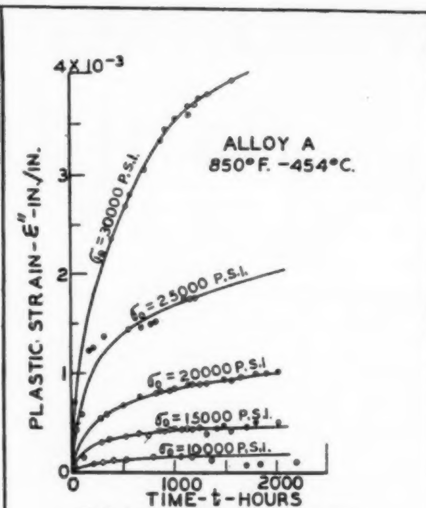

FIG. 3:- ORIGINAL CREEP CURVES

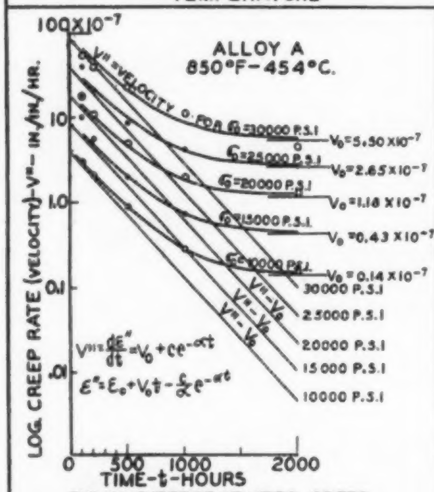

FIG. 4:-DIFFERENTIATED CREEP CURVES FROM FIG. 3

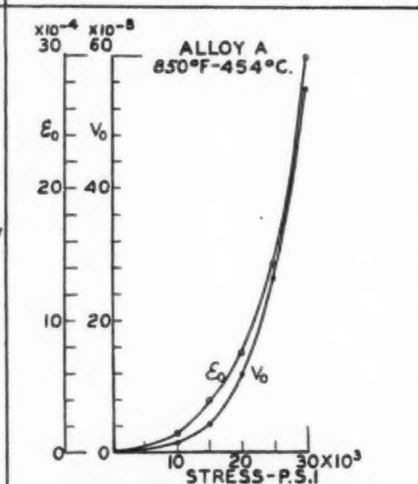

FIG. 5:-EFFECT OF STRESS ON CONSTANTS $\mathcal{E}_0$ AND V_0

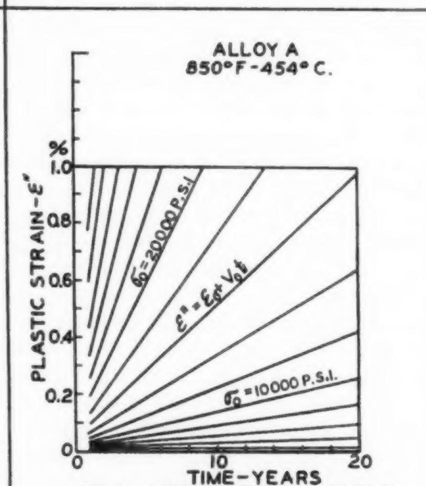

FIG. 6:-ASYMPTOTES OF CREEP CURVES FOR CONSTANT STRESS AND TEMPERATURE

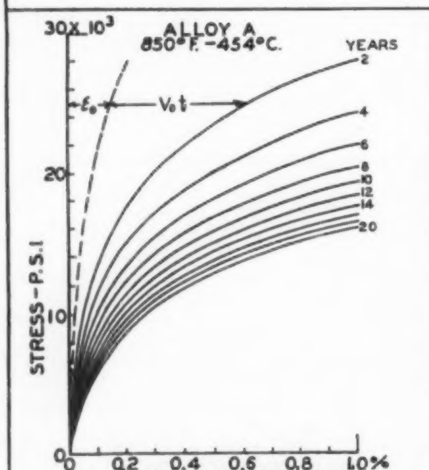

FIG. 7:-STRESS-STRAIN-TIME RELATIONS AT CONSTANT TEMP.

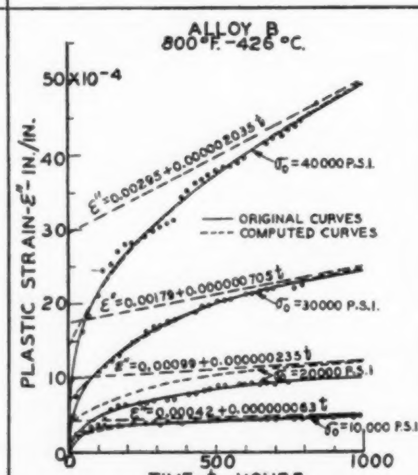

FIG. 8:-ORIGINAL CREEP CURVES
DATA FROM MR. J. J. KANTER, CRANE CO.

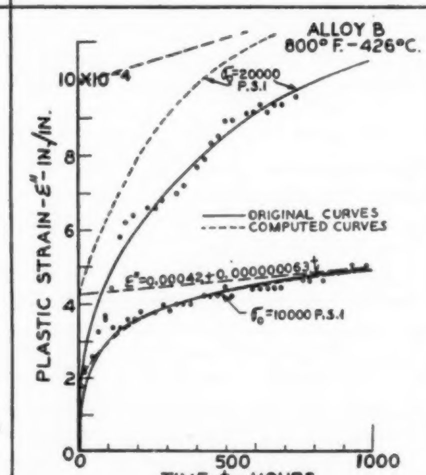

FIG. 9:- ORIGINAL CREEP CURVES
DATA FROM MR. J. J. KANTER, CRANE CO

FIGS. 1 TO 9

(Composition of Alloy A: C = 0.115; Mn = 0.41; P = 0.010; S = 0.025; Si = 0.155; Ni = 0.10; Cr = 12.46 per cent. Composition of Alloy B: C = 0.12; Mn = 0.56; Si = 0.315; Cr = 12.23 per cent.)

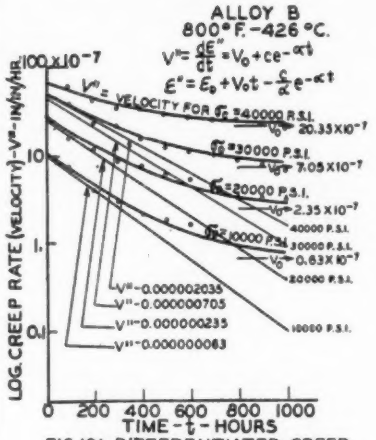

FIG.10:-DIFFERENTIATED CREEP CURVES FROM FIGURES 8 & 9

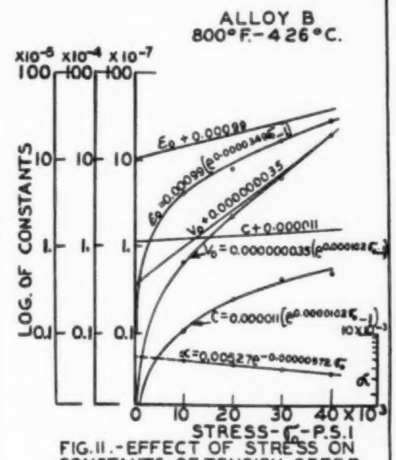

FIG.11.-EFFECT OF STRESS ON CONSTANTS OF TENSION CREEP CURVES

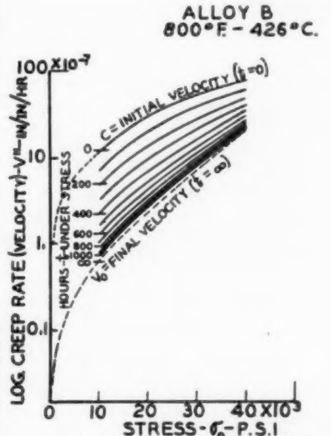

FIG.12:-VELOCITY-STRESS-TIME RELATIONS AT CONSTANT TEMP.

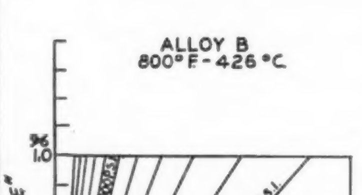

FIG.13:-ASYMPTOTES OF CREEP CURVES FOR CONSTANT STRESS AND TEMPERATURE

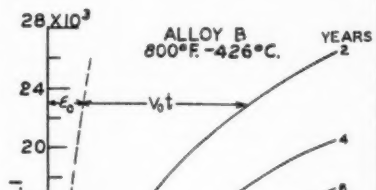

FIG.14:-STRESS-STRAIN-TIME RELATIONS AT CONSTANT TEMP.

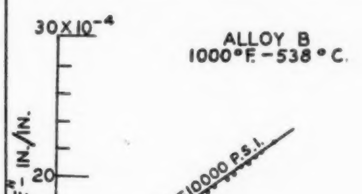

FIG.15:-ORIGINAL CREEP CURVES
DATA FROM MR. J.J. KANTER (CRANE CO.)

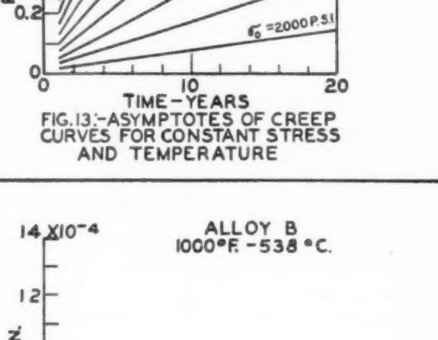

FIG.16:-ORIGINAL CREEP CURVES
DATA FROM MR. J.J. KANTER (CRANE CO.)

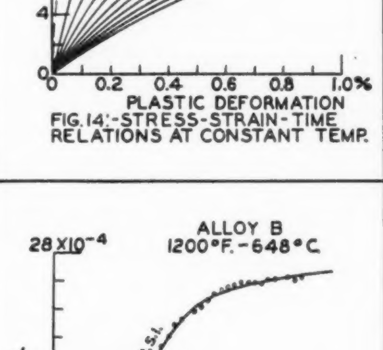

FIG.17:-ORIGINAL CREEP CURVES
DATA FROM MR. J.J. KANTER (CRANE CO.)

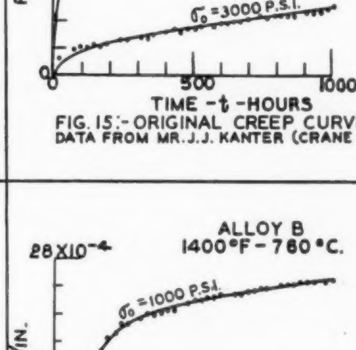

FIG. 18:-ORIGINAL CREEP CURVES
DATA FROM MR. J.J. KANTER (CRANE CO.)

FIGS. 10 TO 18
(Composition of Alloy B: C = 0.12; Mn = 0.56; Si = 0.315; Cr = 12.23 per cent.)

ϵ'' = plastic or permanent part of strain ϵ (creep)
E = modulus of elasticity
σ = stress (computed for actual cross-sectional area A of bar)
σ_0 = stress (computed for original cross-sectional area A_0 of bar)
t = time
v = total rate of strain = $d\epsilon/dt$
v' = elastic rate of strain which is zero in the case of constant stress considered here
v'' = plastic rate of strain = $d\epsilon''/dt$ (creep rate)
θ = temperature
η = viscosity coefficient for pure shear
ϕ = viscosity coefficient for tension = 3η

In Fig. 1 the curves representing short-time and long-time tension tests at a constant elevated temperature have been combined to show the relation between them. This method of representation shows also how the effects of creep during various periods of time may be added to the conventional stress-deformation curve[9] as a means of representing the essential information obtained from a family of creep curves. Being limited in time to the actual duration of the creep tests, it is necessary either to extend the creep tests to periods of time comparable with service life or to extrapolate curves representing relatively short tests. While the practise is open to objections,[2] the commonly used straight-line extrapolation of creep curves may be accepted for practical purposes until more complete information as to the true nature of the creep-time curve $\epsilon = f(t)$ over several years is obtained.

TWO TYPES OF CREEP CURVES

Fig. 2 represents two types of creep curves. In one, the curve follows what is essentially a straight line during a substantial portion of the test. The other shows a continuously decreasing creep rate throughout the test. The direct straight-line extrapolation of the first is the best available procedure but the second offers more difficulty. The use of a final tangent to the second type of curve frequently leads to unduly conservative estimates of deformation and of working stresses. It will be shown that an asymptote to this type of curve is preferable for the purpose of extrapolation and that it offers the advantage of a reduced testing time. In either case, the possibility of an inflection[2] within the service life must be excluded just as it is when a definite creep rate is associated with each combination of stress and temperature.[10]

Fig. 3 represents a family of creep curves of the latter type, the tests all being made at 850 F (454 C) using equipment and methods previously described[10,11,12] as applied to a forged and heat-treated stainless iron furnished by N. L. Mochel. To interpret such a family of curves, both interpolation and extrapolation are necessary; the former in respect to stress and the latter in respect to time. The interpolation between zero stress and the lowest stress actually tested is fully as important as the extrapolation from the duration of the test to a time representing service life.

Studies of families of curves similar to Fig. 3 have shown that, at constant stress and temperature, in the first portion of the creep curves the excess of creep velocity above a certain minimum creep rate v_0 decreases very nearly geometrically as time t increases arithmetically. This suggests an exponential relation between creep velocity v'' and time t of the form

$$v'' - v_0 = ce^{-\alpha t} \quad \text{[1]}$$

in which v_0 is a constant and $v'' = d\epsilon''/dt$ (the slope of the creep curve). Assuming further that the parameters v_0, c, and α depend only upon the stress σ at constant temperature θ, we may assume that they remain constant during a test at constant stress and temperature.

EQUATION OF CREEP CURVES

By integration of Equation [1] with respect to the time t, an equation representing the original creep curve may be written:

$$\epsilon'' = \epsilon_0 + v_0 t - \frac{c}{\alpha} e^{-\alpha t} \quad \text{[2]}$$

It is, of course, impossible to say that this is the equation for the creep curve, but application to many tests of different materials has shown that such a curve with properly chosen constants closely follows the original data during periods of time for which creep tests have been conducted. The assumption that the creep curve for constant stress and temperature is one having a straight-line asymptote is equivalent to an assumption of viscous flow in the second stage of creep. If the metal is structurally stable, it is reasonable to assume that, below certain upper limits for stress and temperature, the viscosity coefficient η for pure shear remains for a constant stress σ practically constant so that the creep rate v'' approaches a minimum value v_0 which may be considered also to remain practically constant over long periods of time such as the service life of the material. The validity of this assumption may be verified by a study of the relation between creep velocity and plastic strain for several stresses at the same temperature.[13] It is impossible within the scope of this paper to discuss more fully this phase of the problem, but the only reasonable conclusion is that the time at or near the minimum creep rate for low stresses must be extremely long. If it is necessary to justify extrapolation of the creep curve in respect to time it may be done by reference to the $v'' - \epsilon''$ relations.

Space limitations prevent a discussion of the various possible methods of determining the constants in Equations [1] and [2]. One approach is illustrated in Fig. 4 in which the points shown were obtained by differentiation of the curves in Fig. 3 at the end of five different periods of time while the curves represent Equation [1] and show means of obtaining the constants v_0, c, and α. The value of ϵ_0 in Equation [2] is obtained by substitution of corresponding known values of ϵ'' and t. Theoretically, ϵ_0 should be equal to c/α when $t = 0$. In some cases, this gives undue importance to the first few hours of the test and the resulting curve does not follow the points as well as that obtained by the method suggested.

PREDICTING DEFORMATIONS GREATER THAN THOSE OF THE CREEP TEST

Any attempt to predict deformations in times greater than those of the creep test may be based on the asymptote of Equation [2] which may be written:

$$\epsilon'' = \epsilon_0 + v_0 t \quad \text{[3]}$$

[9] "Testing of Materials at Elevated Temperatures," by P. G. McVetty, Proc. A.S.T.M., vol. 28 (1928), part 2, p. 69.

[10] Report of Committee A-10, "Safe Working Stresses at Elevated Temperatures," Proc. A.S.T.M., vol. 30 (1930), part 1, Appendix, plates 5, 7, and 9.

[11] "The Tensile Properties of Metals at High Temperatures," by T. D. Lynch, N. L. Mochel, and P. G. McVetty, Proc. A.S.T.M., vol. 25 (1925), part 2, pp. 5–52.

[12] P. G. McVetty in a discussion of a paper by H. J. French entitled "Methods of Test in Relation to Flow of Steels at Various Temperatures," Proc. A.S.T.M., vol. 26 (1926), part 2, pp. 25–30.

[13] The author is indebted to R. Beeuwkes, Jr., of the Westinghouse Research Laboratories, for permission to refer to his excellent investigation of these relations, the results of which have not yet been published.

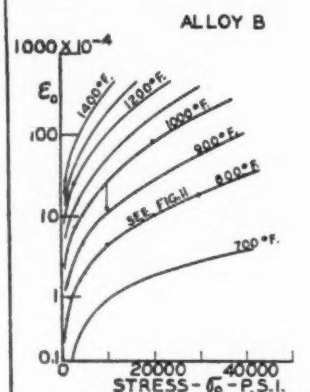

FIG. 19:- EFFECT OF STRESS ON CONSTANT - ε_0

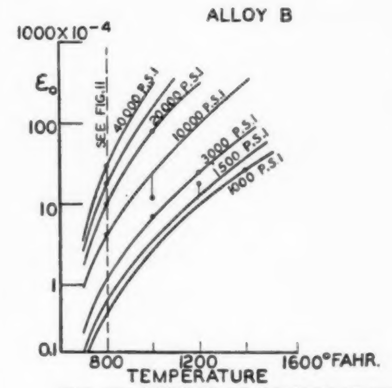

FIG. 20:- EFFECT OF TEMPERATURE ON CONSTANT - ε_0

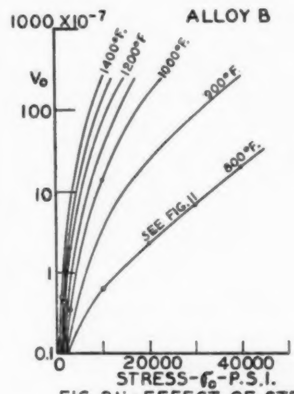

FIG. 21:- EFFECT OF STRESS ON CONSTANT - V_0

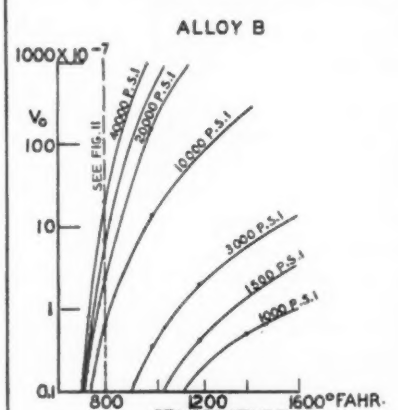

FIG. 22:- EFFECT OF TEMPERATURE ON CONSTANT - V_0

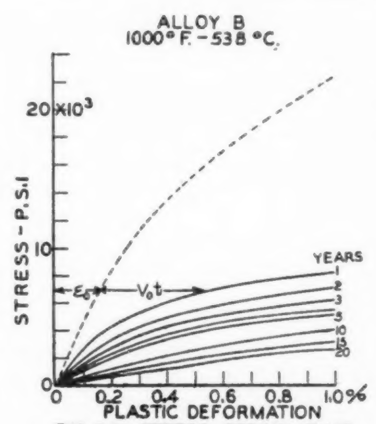

FIG. 23:- STRESS-STRAIN-TIME RELATIONS AT CONSTANT TEMP.

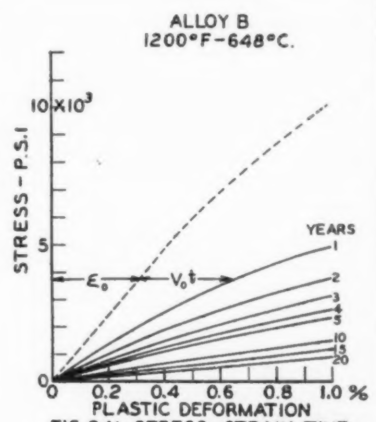

FIG. 24:- STRESS-STRAIN-TIME RELATIONS AT CONSTANT TEMP.

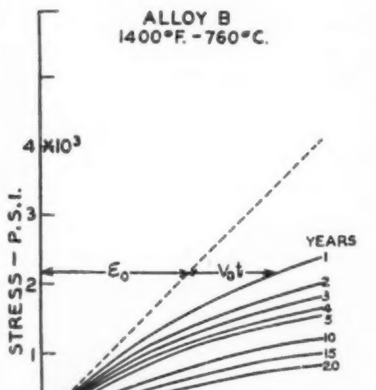

FIG. 25:- STRESS-STRAIN-TIME RELATIONS AT CONSTANT TEMP.

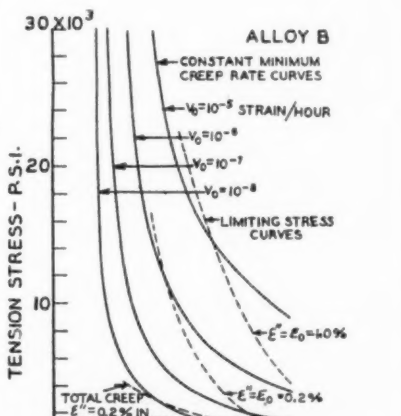

FIG. 26:- EFFECT OF PRIMARY CREEP ON STRESS-TEMPERATURE RELATIONS

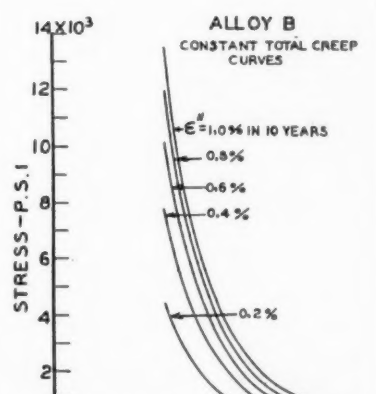

FIG. 27:- EFFECT OF ALLOWABLE DEFORMATION ON STRESS-TEMP. RELATIONS

FIGS. 19 TO 27

(Composition of Alloy B: C = 0.12; Mn = 0.56; Si = 0.315; Cr = 12.23 per cent.)

in which the constants are known for the particular combinations of stress and temperature for which tests have been made. In the simpler case in which the creep curve itself follows a straight line capable of direct extrapolation, a similar equation may be written and the constants determined from the intercept and slope of the curve. In this way, tests for various periods of time may be extrapolated and compared under more favorable conditions than would result from the use of the final tangent. Such data are, however, limited to stresses for which tests have been conducted.

If the reasonable assumption is made that both ϵ_0 and v_0 equal zero when the stress is zero it is possible to plot the values of these constants as functions of stress as shown in Fig. 5. Taking values of ϵ_0 and v_0 from these curves, the extrapolated creep curves for any stress within the range studied may be drawn as shown in Fig. 6. In applying this method, it must be remembered that inflections in the creep curves may be expected at the higher stresses and temperatures[3] and that such inflections make the proposed method invalid. For that reason the curves in Fig. 6 have been terminated at a plastic strain of one per cent on the assumption that the deformation usually exceeds this value before inflections are found. Further experience with the application of the proposed method may indicate a change in this arbitrarily assumed limit of plastic deformation prior to inflections, but this may be made without affecting the validity of other assumptions.

The relations among the three variables, stress, deformation, and time at constant temperature, as given in Fig. 6, may be put into more convenient form as shown in Fig. 7 by the method illustrated in Fig. 1. The method of presentation indicated in Fig. 7 is suggested as a convenient form for the comparison of test data and for design use.

EFFECT OF TEMPERATURE

For the particular material used in the foregoing discussion, complete data were available at only one temperature. To investigate the effect of the fourth variable, temperature, use was made of valuable test data on a similar alloy very kindly furnished for the purpose by J. J. Kanter, of the Crane Company. The test methods used for obtaining these data[14] are somewhat different from those of the author, but the proposed method of analysis is equally applicable as shown in Figs. 8 to 14, inclusive. Two of these figures require further comment. In Fig. 11, an attempt was made to establish relations between stress and the constants of the creep equation. While this method has some advantages over the simpler procedure shown in Fig. 5, the use of logarithms of the constants prevents full utilization of the desirable assumption that the curves pass through the origin. From the applications made up to the present time it appears that the method of Fig. 5 is preferable to that of Fig. 11.

Fig. 12 shows creep-rate relations at the end of various periods of time. The final velocity for each stress is the same as the v_0 value of Fig. 10 corresponding to the asymptote of the velocity-time curve. These curves representing a material in which the creep rate decreases continuously during a test of 1000 hours gives some indication of the probable effect of length of test upon the minimum creep rate measured. For this material it appears that very little would have been gained by prolonging the test beyond 1000 hours.

An approximate method of analysis for the reduction of the data for 1000 F, 1200 F, and 1400 F to charts similar to Figs. 7 and 14 is shown in Figs. 15 to 25, inclusive. At these higher temperatures the validity of extrapolation of the creep curves is reduced on account of probable inflections.[3] While the accuracy of this extension of the analysis is questionable, it throws some light on a problem which has been rather obscure. Bailey,[15] Tapsell,[16] and others have shown the effect of temperature upon allowable stress for various minimum creep rates. With the exception of the work of Mr. Kanter,[14] very little has been published to indicate stress-temperature relations for various amounts of total creep within the life of the material in service. Bailey, *et al.*, in their reply to Mr. Kanter's discussion[15] defend the use of creep rate rather than total creep by stating that it avoids a treatment "too unwieldly for practical purposes." A comparison of the two methods is shown in Fig. 26. From these curves, two important conclusions may be drawn. The stress-temperature relation is not fixed by a given creep rate but it is necessary also to allow for the creep at a more rapid rate in the early stage of the test. Furthermore, the rapid decrease in allowable stress indicated by the constant creep-rate curves may be replaced by decidedly flatter curves based on total creep. For the case in which the allowable stress at one temperature is known and it is desired to estimate a working stress for a higher temperature, this type of curve is suggested.

Fig. 27 represents the type of chart which may be constructed from charts similar to Figs. 14, 23, 24, and 25 for any desired combination of service life and allowable deformation. In this way it is possible to show graphically the desired relations among the four variables, temperature, stress, deformation, and time in a form convenient for design use.

Similar analyses have been applied to other materials from various sources with promising results. Application to tests of two non-ferrous alloys at two slightly elevated temperatures showed practically straight-line creep curves in tests of two months' duration. In this case the entire analysis required only the plotting of curves similar to Figs. 3, 5, and 7 for each material at each temperature. This indicates that further investigation of the subject of analysis of creep data may lead to simpler methods than those suggested here.

In conclusion, the assumption has been introduced that the long-time tension or creep curve approaches a straight line in a comparatively short time and that it may be replaced by a straight line for the purpose of extrapolation. Relations are established between creep properties and stress which indicate a possibility of avoiding very long creep tests at low stresses for the assignment of safe working stresses. A systematic method of interpretation of creep data is suggested as a means of correlating existing data from various sources and the reduction of such data to a form that will be convenient for comparison.

ACKNOWLEDGMENTS

The author wishes to acknowledge his indebtedness to Dr. A. Nadai for his unfailing interest, encouragement, and helpful criticism and suggestions; to Messrs. C. E. Crang and K. R. Waugh for their conduct of creep tests and to Mr. R. E. Peterson and the Westinghouse Electric and Manufacturing Company for permission to publish the results.

[14] "Long-Time or Flow Tests of Carbon Steels at Various Temperatures With Particular Reference to Stresses Below the Proportional Limit," by J. J. Kanter and L. W. Spring, Proc. A.S.T.M., vol. 28 (1928), part 2, pp. 80–106.

[15] "The Trend of Progress in Great Britain on the Engineering Use of Metals at Elevated Temperatures," by R. W. Bailey, J. H. S. Dickenson, N. P. Inglis, and J. L. Pearson, Symposium on Effect of Temperature on Metals, A.S.M.E.-A.S.T.M., pp. 227–231, 1932.

[16] "The Strength at High Temperatures of a Cast and a Forged Steel as Used for Turbine Construction," by H. J. Tapsell and A. E. Johnson, Department of Scientific and Industrial Research (London), Special Report No. 17, 1931.

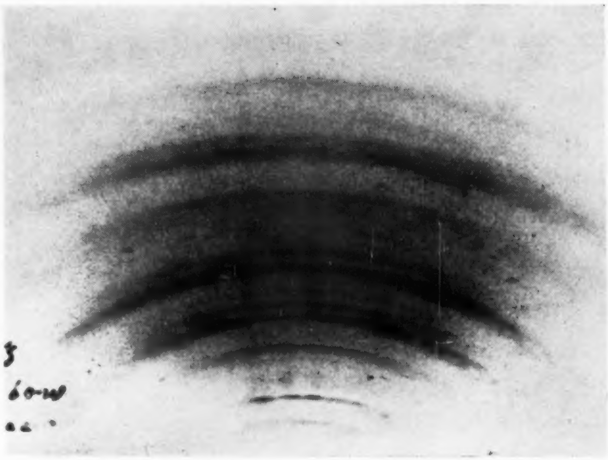

FIG. 1 SAMPLE NO. 3 ETCHED TO 0.0033 IN. BELOW SURFACE

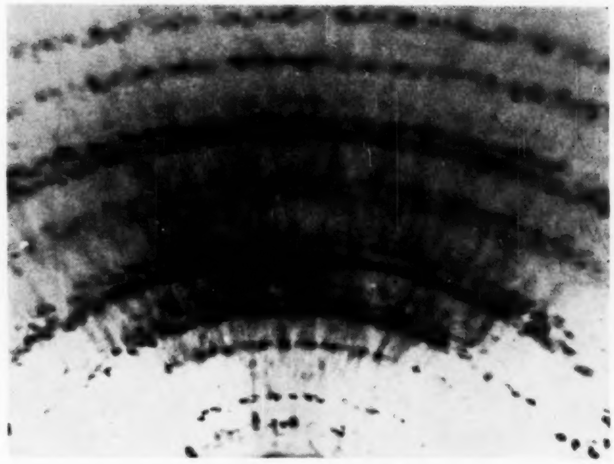

FIG. 2 SAMPLE NO. 8 ETCHED TO 0.0050 IN. BELOW SURFACE

X-Ray Determination of DEPTH *of* COLD WORKING *by Machining*

By L. THOMASSEN[1] and D. M. McCUTCHEON[2]

CONSIDERABLE INTEREST has been shown by mechanical engineers in the depth of cold working produced by machining metals and alloys.[3] Hardness determinations are generally used for measuring this quantity; but it should be kept in mind that this method measures only one of the effects of cold work, namely, work hardening, which will vary in magnitude for the same amount of work from one material to another. A determination of depth of cold working by hardness measurements on a material which work hardens very little must obviously be inaccurate.

When annealed metals and alloys are severely cold worked the original grains will be deformed under formation of slip planes and changes in crystal orientation, thus obliterating the original grain structure. This effect is observed in X-ray-diffraction photographs by the appearance of continuous rings forming a true Hull-Debye-Scherrer picture (Fig. 1), instead of the separate double lines or spots which are reflected from the individual grains and are characteristic of the annealed material (Fig. 4). Less severe working will destroy the regularity of the space lattice by removing a certain number of atoms from their equilibrium positions and is particularly noticeable by a broadened and washed-out appearance of the spots (Fig. 2). The pictures shown are all photographed by the molybdenum characteristic radiation.

We may define "depth of cold working" as the distance below the surface at which the effect of lattice deformation is no longer noticeable in the X-ray-diffraction picture. This quantity can be determined as follows: After annealing, an X-ray picture is taken of the sample as a record of the structure. The machining operation is then carried out under conditions as carefully controlled as possible, the machined surface is etched to remove a definite thickness of material, and a new X-ray picture is taken and is compared with the first picture. If the two pictures are identical, the new surface produced by etching is below the depth of the cold working. If the effect of work is still evident, the procedure is repeated in small steps until a picture is obtained which shows the same structure as was shown in the first picture. The total thickness of material removed by etching is then the depth of cold working.

Grinding off the surface for photographing instead of etching is out of the question, since grinding produces complete fragmentation of the surface grains and also comparatively deep cold working.

The success of the above method is due to the fact that surface layers of less than 0.001 in. will produce practically all the diffracted rays, when the beam of X-rays is directed against the flat sample of metal, for instance, brass, under an angle of 10 deg. This gives a powerful method for investigating the structure of thin layers even when they change quite rapidly in character from the surface inward, as is the case here.

[1] Assistant Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich.

[2] University of Michigan.

[3] "Effect of Lathe Cutting Conditions on the Hardness of Carbon and Alloy Steels," by T. G. Digges. Paper presented at the Annual Meeting, New York, N. Y., December, 1933, of The American Society of Mechanical Engineers.

Contributed by the Special Research Committee on Cutting of Metals and presented at the Session on Metal Cutting, Stevens Institute of Technology, Hoboken, N. J., December 6, 1933, of the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of The American Society of Mechanical Engineers.

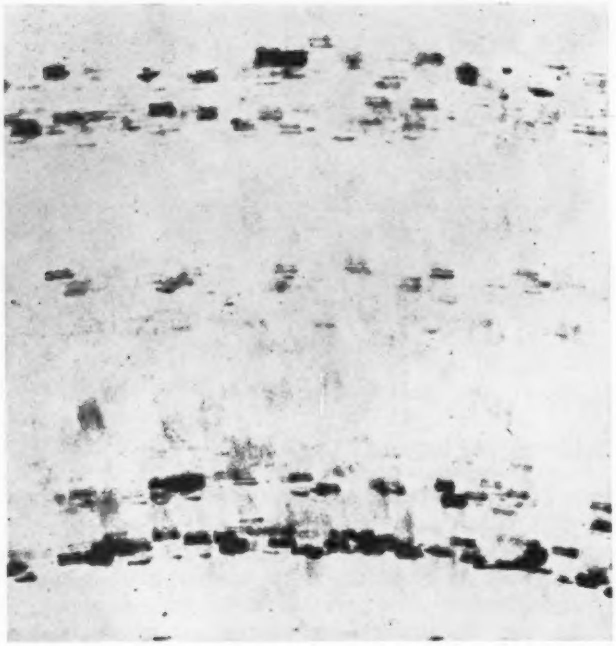

FIG. 3 SAMPLE NO. 8 ETCHED TO 0.0095 IN. BELOW SURFACE
(Original enlarged three times.)

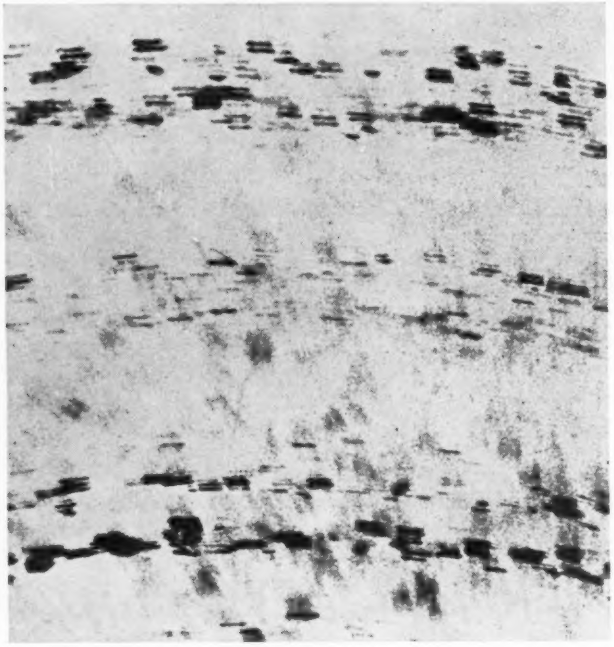

FIG. 4 SAMPLE NO. 8 ETCHED TO 0.0112 IN. BELOW SURFACE
(Original enlarged three times.)

EXPERIMENTAL PROGRAM

Milling Operations. Samples of cold-rolled 70–30 brass were annealed to produce a grain size of approximately 0.08 mm. For the milling operations, Brown and Sharpe end-mill cutters 1 in. in diameter with six teeth were used. The cutter in Table 1 was new as purchased, while the one called "dull" was similar but worn.

The result of this work is shown in Table 1 and graphically

TABLE 1 RESULTS OF MILLING TESTS

Sample no.	Depth of cut, in.	Next-to-Last Etch: Depth, in.	Next-to-Last Etch: Picture	Last Etch: Depth, in.	Last Etch: Picture
1	0.004	0.0021	Mainly spots	0.0034	Spots sharp
2	0.016	....	....	0.0047	Spots sharp
3	0.032	0.0041	Almost sharp	0.0046	Spots sharp
4	0.064	0.0053	Almost sharp	0.0069	Spots sharp
5[a]	0.0166	0.0166	Rings and spots	0.0220	Spots sharp
6[b]	0.064	....	....	0.0078	Almost sharp
7[c]	0.064	....	....	0.0068	Almost sharp

[a] Dull cutter.
[b] Feed, 0.014 in. per revolution.
[c] 342 rpm.

in Fig. 5. In the diagram the difference in thickness between the point where the annealed structure is obtained and the preceding one is indicated by a vertical line.

Turning Operations. The material used was a leaded brass analyzing 61.7 per cent Cu, 35.0 per cent Zn, and 3.2 per cent Pb. After annealing the samples were turned under the following conditions: Cuts were taken on a Springfield tool-room lathe equipped with a dynamometer[4] to measure the force on turning. With a set-up of 94 rpm, the cutting speed was approximately 40 fpm. The tool was of a shape almost universally used for brass cutting and had the following angles: 0-deg back and side rake, 6-deg front and side clearance, 10-deg end cutting angle, and a 0.010-in. nose radius. Cutting was done dry. The results are shown in Table 2 and in Figs. 6 and 7.

To illustrate the method, Fig. 1 shows a reproduction of the X-ray picture obtained from sample No. 3 etched to 0.0033 in. below the machined surface. The broad continuous lines are characteristic of the obliterated grain structure. Fig. 2 shows a picture of sample No. 8 etched 0.0050 in. Blurred

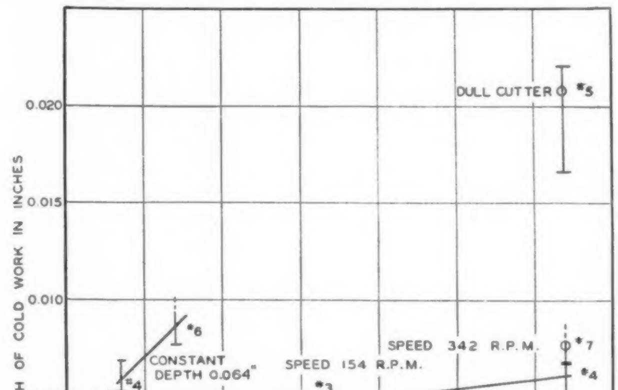

FIG. 5 RESULTS OF MILLING TESTS

crystal diffraction spots begin to appear superimposed on the continuous rings. Fig. 3 is a picture of the same sample etched to 0.0095 in. showing almost sharp double lines. This may be compared with Fig. 4 of the same sample but 0.0112 in. below the surface. As will be seen, the double lines are on the whole more clear cut than in Fig. 3. Fig. 4 is characteristic of the annealed structure and will not change on further etch-

[4] Described by O. W. Boston and C. E. Kraus, Trans. Am. Soc. Steel Treating, vol. 21 (1933), p. 623.

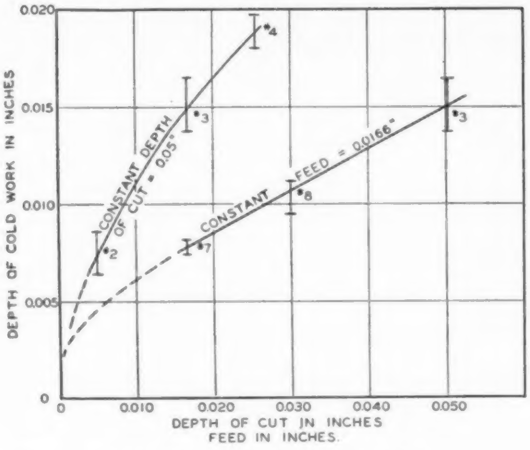

FIG. 6 RESULTS OF TURNING TESTS

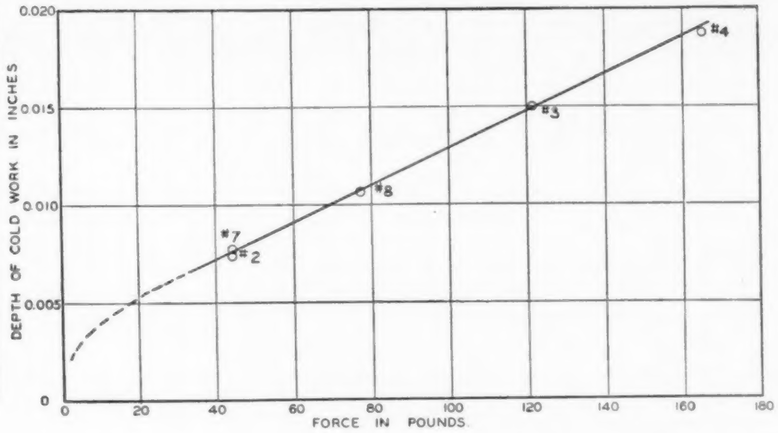

FIG. 7 DEPTH OF COLD WORK AS A FUNCTION OF CUTTING FORCES

TABLE 2 RESULTS OF TURNING TESTS

Sample no.	Depth of cut, in.	Feed, in. per rev	Cutting force, lb	Next-to-Last Etch Depth, in.	Next-to-Last Etch Picture	Last Etch Depth, in.	Last Etch Picture
1	0	0	0	0.0055	Sharp	0.0080	Sharp
2	0.0495	0.0052	44	0.0064	Almost sharp	0.0086	Sharp
3	0.051	0.0166	121	0.0137	Almost sharp	0.0165	Sharp
4	0.0495	0.0256	165	0.0180	Almost sharp	0.0197	Sharp
5[a]	0.015	0.0166	44	0.0034	Rings and spots	0.0095	Sharp
6[b]	0.030	0.0166	77	0.0095	Almost sharp	0.0150	Sharp
7	0.015	0.0166	44	0.0075	Almost sharp	0.0082	Sharp
8	0.030	0.0166	77	0.0095	Almost sharp	0.0112	Sharp

[a] Left out of graph since repeated experiment with sample No. 7 gives a closer value.

[b] Left out of graph since repeated experiment with sample No. 8 gives a closer value.

ing. The two last pictures have been enlarged three times from the original negative to bring out the double lines.

DISCUSSION OF RESULTS

(1) The depth of cold working increases more rapidly with increase in feed than with increase in the depth of cut for the tools and materials used. In milling (see Fig. 5), a doubling of the feed from 0.007 to 0.0014 in. increases the depth of working from about 0.006 to 0.0085 in., or about 40 per cent, while a doubling in the depth of cut from 0.016 to 0.032 in. increases the depth of cold work from 0.0039 to 0.0046 in., or about 20 per cent. For the turning operations (Fig. 6), a doubling of the feed from 0.010 to 0.020 in. increases depth of cold working from 0.011 to 0.0165 in., or 50 per cent, while the corresponding increase in feed only brings about an increase in depth of cold work from 0.006 to 0.0085 in., or 25 per cent.

Comparing these results with those of Digges for steels and assuming that work hardening as determined by him is proportional to depth of cold work as determined here, a discrepancy will be noted, since Digges states that work hardening is increased equally by changes either in feed or in depth of cut.

(2) Fig. 7 shows the depth of cold working in turning plotted as a function of the cutting force. The connection is a strictly linear one.

(3) An increase in depth of cold work of over 300 per cent is found on using a dull cutter instead of a sharp one in the milling experiments. According to the results obtained above, this depth of cold work would indicate a great force expended on cutting. A pronounced orientation of the crystalline structure was found in this sample, similar to that observed on cold rolling. This effect was noticed even at a depth of 0.0115 in. below the machined surface.

(4) Increase in speed of milling from 154 to 342 rpm does not increase the depth of work appreciably.

ACKNOWLEDGMENTS

The authors are indebted to W. A. Pearl who carried out the milling experiments. They are very grateful to Prof. O. W. Boston, Director of the Department of Engineering Shops, for the loan of milling cutters, and for illuminating discussions on the art of metal cutting. C. E. Kraus, of the same department, kindly prepared the latter samples and also took readings of the turning forces.

Manufacturing Costs and Prices Under the NRA

(Continued from page 143)

can advantageously sell at, as a limiting price, a figure representing direct cost only: that such a policy may be preferable to a complete or partial shut-down: that up to total overhead and total profit may justifiably be recouped from a part only of total sales. The economic principles underlying are two: the separation of constant and variable costs (overhead and direct costs), and the price-demand relationship (demand increases when price is reduced).

It is worth discussion, therefore, whether the best type of stipulation in a code should not follow the lines of the retail code, merely forbidding selling at less than the (individual) out-of-pocket costs; whether codes should permit selling surplus products, which cannot otherwise be sold, down to this level. Does this involve "destructive" price cutting? Is such class pricing to be regarded as exceptional and of an emergency nature, or is it worth consideration as a permanent and fundamental policy?

It would be repugnant to some ideas of what constitutes fairness, but such ideas have had to be revised in various directions in the recent past. Class pricing would be extremely difficult to regulate. The attitude of the trade associations is largely hostile. That of governmental authorities is probably, at the moment, unfavorable to its comprehensive permanent application. But it does seem to offer certain social values.

E.C.P.D.—A Conference of Engineering Bodies

CHARTER AND RULES OF PROCEDURE

PREAMBLE

THE Engineers' Council for Professional Development, organized October 3, 1932, resulted from the Conference on Certification, made up of representatives of seven engineering bodies, which was instituted at an earlier date for the consideration of that subject. The recommendations of this conference, with a statement of objectives, method of operation, and an initial program, were embodied in a "Plan for Joint Action." The following bodies approved the plan and voted to participate in the new organization:

American Society of Civil Engineers
American Institute of Mining and Metallurgical Engineers
The American Society of Mechanical Engineers
American Institute of Electrical Engineers
Society for the Promotion of Engineering Education
American Institute of Chemical Engineers
National Council of State Boards of Engineering Examiners.

The charter which follows embodies the objectives, program, and method of operation included in the "Plan for Action," and hence approved by the participating bodies. A provision for making changes in the charter has been added.

CHARTER

1 *Description and Participating Bodies.* The Engineers' Council for Professional Development, hereinafter referred to as E.C.P.D., is a conference of engineering bodies organized to enhance the professional status of the engineer through the cooperative support of those national organizations directly representing the professional, technical, educational, and legislative phases of an engineer's life. The participating bodies are the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

2 *Objectives.* The general objective of E.C.P.D. is the enhancement of the professional status of the engineer. To this end it aims to coordinate and promote efforts and aspirations directed toward higher professional standards of education and practise, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems.

An immediate objective, now apparently practicable of attainment, is the development of a system whereby the progress of the young engineer toward professional standing can be recognized by the public, by the profession, and by the man himself, through the development of technical and other qualifications which will enable him to meet minimum professional standards.

3 *Program.* E.C.P.D. shall proceed with the following program:

(*a*) To develop further means for the educational and vocational orientation of young men with respect to the responsibilities and opportunities of engineers, in order that only those may seek entrance to the profession who have the high quality, aptitude, and capacity which are required of its members.

(*b*) To formulate criteria for colleges of engineering which will insure to their graduates a sound educational foundation for the practise of engineering.

(*c*) To develop plans for the further personal and professional development of young engineering graduates, and also of those without formal scholastic training.

(*d*) To develop methods whereby those engineers who have met suitable standards may receive corresponding professional recognition.

4 *Method of Operation.* E.C.P.D. shall from time to time recommend to the governing boards of the participating bodies, procedures considered to be of value or significance in promoting the general objective set forth in Par. 2, and shall administer such procedure as shall have been approved by those boards.

5 *Changes.* Changes in the charter shall be made only after approval by the governing boards of two-thirds of the participating bodies.

RULES OF PROCEDURE

RULE 1 REPRESENTATION

Each participating body shall have three representatives on E.C.P.D. Each representative shall be appointed for a term of three years beginning at the close of the annual meeting.[1] The term of one representative in the delegation of each participating body shall expire each year. Representatives shall not serve more than two consecutive terms.

Vacancies in the delegation of a participating body shall be filled by that body.

The representatives of each participating body shall be charged with the responsibility of providing its governing board with current information about the plans, program, and proceedings of E.C.P.D., supplementing the reports of the secretary, and of ascertaining the official attitude of its governing board on matters under discussion before E.C.P.D.

RULE 2 OFFICERS AND EXECUTIVE COMMITTEE

At each annual meeting, E.C.P.D. shall elect from the representatives of participating bodies a chairman to serve for one year, beginning at the close of that meeting. The chairman shall perform the duties usual to his office or assigned by the executive committee. In his absence, his duties shall be performed by a representative designated by E.C.P.D. or by the executive committee.

At each annual meeting, E.C.P.D. shall elect a secretary to serve one year, beginning at the close of the annual meeting. The secretary need not be a representative of a participating body. The secretary shall perform the duties usual to the office. In addition, he shall be responsible for providing the secretaries of the participating bodies with complete current information about the plans, program, and proceedings of E.C.P.D.

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[1] At the time of the first annual meeting, the terms for which the three representatives from each body are appointed shall be one, two, and three years, respectively.

At each annual meeting, E.C.P.D. shall elect an executive committee, made up of one representative of each participating body. In addition, the chairman shall be a member of the executive committee and chairman *ex-officio*. The secretary shall be secretary *ex-officio* and may participate in the deliberations, without vote.

The executive committee shall perform such duties as are assigned it. During the intervals between the meetings of E.C.P.D., the executive committee shall have and exercise all its general powers except the approval of recommendations to the governing boards of the participating bodies. The executive committee may, however, act for E.C.P.D. on such recommendations, provided that there shall have been secured by letter ballot the approval of a majority of the representatives of each participating body, such action to be confirmed by E.C.P.D. at its next meeting. The executive committee shall be responsible for making public the work of E.C.P.D. It shall also concern itself with the relations between E.C.P.D. and other engineering professional bodies with a view to bringing about mutual understanding and cooperation.

RULE 3 MEETINGS

E.C.P.D. shall hold an annual meeting in October for the election of officers, the appointment of committees, the adoption of an annual report, and other business. Other meetings may be called by the chairman. Thirty days' notice shall be given for all meetings of E.C.P.D.

RULE 4 COMMITTEES

E.C.P.D. shall appoint the committees necessary to the attainment of its objectives. Committee members may be selected from the engineering profession without regard to society affiliation. Committees shall be of two types, standing and special.

Standing committees shall have the same number of members as there are bodies participating in E.C.P.D. The term of each member of a standing committee shall be three years, beginning at the close of the annual meeting at which he is appointed.[2] The terms shall be arranged so that approximately one-third of the members of each committee will retire each year. Members of standing committees shall not serve more than two consecutive terms.

Special committees shall be appointed for specific assignments. When the assignment is completed and report rendered, the special committee shall be considered discharged.

Vacancies shall be filled by the executive committee with the concurrence of the respective committee chairman.

All committees shall select their own secretaries, who shall perform the duties usual to that office. Chairmen of all committees are *ex-officio* members of E.C.P.D. without vote.

[2] At the time of the first annual meeting, standing-committee members shall be appointed for terms of one, two, and three years.

RULE 5 DUTIES OF STANDING COMMITTEES

The following committees are standing committees:
- Committee on Student Selection and Guidance
- Committee on Engineering Schools
- Committee on Professional Training
- Committee on Professional Recognition.

The Committee on Student Selection and Guidance shall report to E.C.P.D. means for the educational and vocational opportunities of engineers in order that only those may seek entrance to the profession who have the high quality, aptitude, and capacity which are required of its members.

The Committee on Engineering Schools shall report to E.C.P.D. means for bringing about cooperation between the engineering profession and the engineering schools. As an immediate step, the committee shall report to the Council criteria for colleges of engineering which will insure to their graduates a sound educational foundation for the practise of engineering.

The Committee on Professional Training shall report to E.C.P.D. plans for the further personal and professional development of young engineering graduates, and also of those without formal scholastic training.

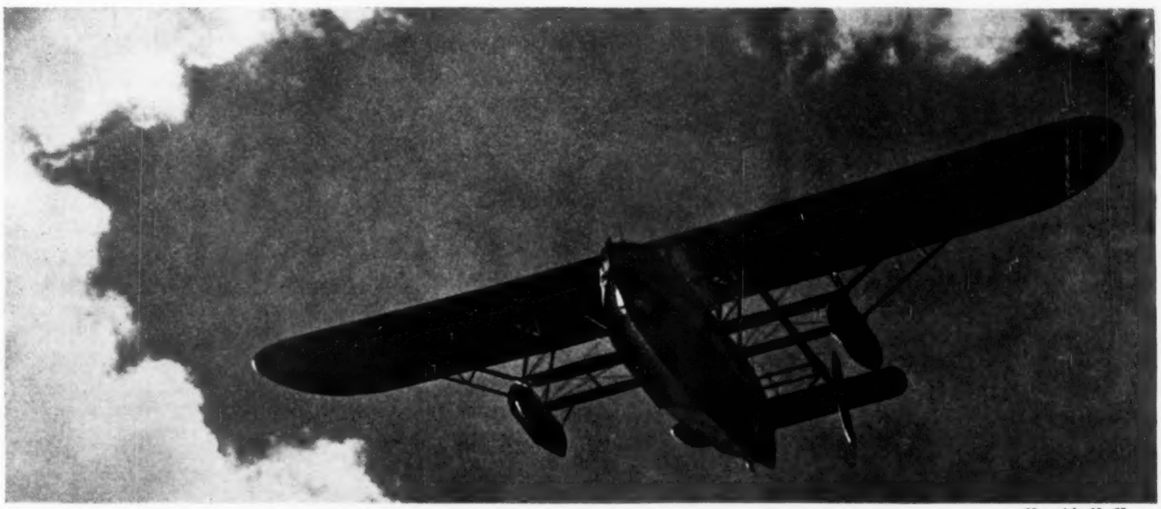
The Committee on Professional Recognition shall report to E.C.P.D. methods whereby those engineers who have met suitable standards may receive corresponding professional recognition.

RULE 6 ANNUAL REPORT

E.C.P.D. shall make an annual report to the governing boards of its participating bodies. This report shall include the annual reports of the standing and special committees, and shall require for approval the affirmative vote of two-thirds of the representatives present at the annual meeting.

RULE 7 CHANGES IN RULES

Changes in the Rules of Procedure may be made at any meeting of E.C.P.D. by a vote of two-thirds of the representatives present.



Nesmith, N. Y.

JAMES HARTNESS, 1861-1934

THE American Society of Mechanical Engineers has lost one of its most honored members, and the profession one of its most distinguished engineers, in the death of Ex-Governor James Hartness, of Springfield, Vermont, after a long illness, on February 2. His loss will be deeply felt by all who have ever known him.

James Hartness was born in Schenectady, N. Y., on September 3, 1861. His father, John W. Hartness, a man of dry, salty humor and keen understanding of human nature, moved to Cleveland in 1863, where he was a foreman in various machine shops. James Hartness was educated in the Cleveland public schools and began learning his trade at sixteen, at a wage of 45 cents a day, first with Younglove, Massey, and Company, of Cleveland, where his father was superintendent, and then in the machine shop of the Union Steel Works. In the latter shop he first came into contact with close, accurate work under Jason A. Bidwell, one of the fine New England mechanics of the older generation. Later, Mr. Hartness went to the Lake Erie Iron Works as a toolmaker. In 1882 he secured a position, through correspondence, as foreman of the Thomson, Stacker Bolt Company in Winsted, Conn. When he reached there the superintendent exploded at the youth of the man whom he had hired. Hartness waited until the storm was over and then offered to release the firm from its contract but to stay until his successor was installed. He remained three years. In 1885 he went to the Union Hardware Company, of Torrington, Conn., manufacturers of gun implements, first as toolmaker, then foreman, and later as inventor. During the year 1888 he worked for a few months each at the Pratt & Whitney Company in Hartford, at Scottdale, Pa., and with the Eaton, Cole, and Burnham Company in Bridgeport.

JAMES HARTNESS

CONNECTION WITH JONES & LAMSON MACHINE COMPANY ESTABLISHED IN 1889

He went to the Jones & Lamson Machine Company in March, 1889, the year in which they moved from Windsor to their present location at Springfield, Vermont. He was at first superintendent until 1893, then manager until 1900, and president from then until his retirement last year. Mr. Hartness' going to the Jones & Lamson Machine Company added another to the list of great mechanics who made the history of this company, or rather the succession of companies of which it is a part. It began about 1838 at Windsor, Vermont, as the Robbins and Lawrence Company, and through the middle of the century, under Richard S. Lawrence, Frederick W. Howe, and Henry D. Stone, this small shop made engineering history. The ever-widening influence of their work is felt to this day. Here was developed and first manufactured the hand-operated turret lathe, the beginnings of the milling machine later known as the Lincoln miller, drop hammers, and many tools adapted to arms manufacture and other types of accurate work. Through various changes the firm became Lamson, Goodnow, and Yale, E. G. Lamson and Company, the Windsor Manufacturing Company, and in 1879 the Jones & Lamson Machine Company. Mr. Hartness brought with him the fundamental ideas of the Hartness flat turret lathe which he had had in his mind for a number of years. He undertook, as superintendent, to develop and manufacture this machine, and in so doing opened up a new period in the history of the company. Like other shops of the time, the successive companies at Windsor had scattered their energies over a wide line. An old "poster" of the Windsor Manufacturing Company shows them offering engine lathes, turret lathes, planers, saw-mill and quarrying machinery, engines and boilers, trip-hammers, sewing machines, rifles, "etc., etc." Things had improved somewhat in this respect, but with the removal of the company to Springfield and the coming of Mr. Hartness there was a radical change. He concentrated its activities on a single size of the flat turret lathe, and the tools for it, dispensed with agents and sold direct, and instituted a new type of sales literature. Under his leadership the company rapidly acquired a world-wide recognition. This is all the more remarkable for its being located in a small town in a Vermont valley six miles off a minor railway, a location, by the way, which he always defended and said he would in no wise change.

SERVICES TO A.S.M.E. AND THE PUBLIC

Mr. Hartness joined The American Society of Mechanical Engineers in 1891. He was a manager from 1909 to 1912, and vice-president in 1912 and 1913. On the German trip of the Society in 1913, President Goss was unable to go and Mr. Hartness, as senior vice-president, acted as head of the party on all the formal occasions. He did this so acceptably to all that he was elected president of the Society in the following year, 1914. He was president of the American Engineering Council from 1924 to 1926, and as a past-president, served as a member of its Assembly for the six years following his presidential term. He therefore held the highest elective positions in the gift of his profession.

His public services were as distinguished as those for the engineering profession. He served his state as chairman of the State Board of Education for six years, was chairman of

the Committee of Public Safety during the War, and also Federal Food Administrator, and, in 1921 to 1923, served as the sixty-first governor of Vermont. In national affairs he was a member of the commission which represented the United States at the Inter-Allied Air Craft Standardization Conferences in London and Paris; and was vice-chairman of the Congressional Screw Thread Standardization Committee.

He was a member of the Society of Automotive Engineers, the Aero Club of America, the American Astronomical Society, a Fellow of the American Association for the Advancement of Science, the Royal Astronomical Society, the Royal Society for Encouragement of Arts, the Royal Societies Club of London, and the Institution of Mechanical Engineers in London. He was awarded the John Scott Medal by the Board of Directors of the City Trusts of Philadelphia, and the Edward Longstreth Medal by the Franklin Institute of Philadelphia.

He is the author of a number of papers before the A.S.M.E., including his presidential address on "The Human Element, The Key to Economic Problems." He also wrote two books, "The Human Factor in Works Management" which was widely distributed, and translated abroad, and "Machine Building for Profit."

He was given the honorary degree of M.E. by the University of Vermont in 1910, honorary M.A. by Yale University in 1914, and LL.D. by the University of Vermont in 1921.

In 1885 he married Lena Sanford Pond, of Winsted, Conn., who died a year ago. He is survived by two daughters, Anna Jackson, who married Dr. William H. Beardsley, and Helen Edith, who married Mr. Ralph E. Flanders.

MR. HARTNESS A PROLIFIC INVENTOR

Mr. Hartness was a prolific inventor and he held patents in this country and abroad for more than 100 inventions. Among these was the flat turret lathe which he began developing from the time of his first coming to Springfield. In the old type of high turret lathes, developed originally by the Robbins and Lawrence Company, the turret revolved about a large vertical pin and all subsequent development had followed that design. Mr. Hartness felt that a stiffer and more accurate construction was possible and investigated the disk turret, the barrel turret, and the flat turret. He settled finally upon the flat turret which appealed to him as offering all the advantages of the old type with possibilities of greater stiffness and precision. It was low, could be clamped at points far apart, and permitted the location of the locking pin directly under the cutting tool. Following out this general design, he developed a lathe which has found wide use here and abroad for the large output of accurate work. Among the improvements were the cross-sliding head in 1903, the double-spindle type in 1910, and the Hartness automatic lathe.

The Lo-Swing and Fay automatic lathes are two more machines invented by him, or greatly influenced by his work. In connection with lathes, he developed many special tools to be used in connection with them, and among these were the well-known Hartness threading dies, which became an important element in the company's business. Associated with these was the Hartness thread comparator, a refined method for the gaging of screw threads by optical means, which not only tells whether the threads are off standard, but precisely wherein they depart from it. He also invented the Hartometer, another type of gage for screw-thread inspection.

HIS INTEREST IN ASTRONOMY

Mr. Hartness' avocations were as interesting as his vocation. He spent four summers on a yacht following down the coast as far as Chesapeake Bay. In 1916 he learned to fly and won an amateur pilot's license. His interest in aviation continued throughout his whole life and he was largely influential in establishing a landing field at Springfield as a memorial to the soldiers and sailors of the World War. It was at this field that Lindbergh landed for his stop in Vermont during the tour of the country after his Paris flight.

For years astronomy claimed his attention. After suffering from a cold acquired in using the old-fashioned type of telescope, he devised the turret equatorial telescope, which was an adaptation of the fundamental idea of the flat turret lathe, wherein a large ring was substituted for one of the axes in the usual equatorial type. This permitted the observer to work inside, under warm and comfortable conditions at all times. One of the happy incidents of the A.S.M.E. trip in 1913 was to run into a model of this type of telescope in the astronomical section of the Deutsches Museum at Munich. This invention was the subject of a valuable paper before the Society at its Annual Meeting in 1911, and gained for him membership in both English and American astronomical societies. It was mounted over an underground room, one of a long series, running under the lawn in front of his home, connected by a heated and air-conditioned tunnel, and containing workrooms, library, and lounging room. Here he did much of his later work, and it formed a unique feature of the home whose charming hospitality will long be remembered.

His interest in astronomy aroused many others, so that there is probably no community of size similar to Springfield where there is such widespread interest in astronomy and in the building of amateur telescopes.

HIS INFLUENCE ON OTHER MEN

An outstanding characteristic of Mr. Hartness' life was his influence on and encouragement of young men. A number of important machines have been developed by men connected with his company and are now being manufactured by other firms. He discovered and helped in various ways many men now well known in the engineering profession, among whom are George O. Gridley, inventor of the Gridley automatic, and vice-president of the New Britain-Gridley Machine Company; Edwin R. Fellows, inventor of the gear shaper, and president of the Fellows Gear Shaper Company; the late William L. Bryant, who was president of the Bryant Chucking Grinder Company; Frederick P. Lovejoy, president of the Lovejoy Tool Company; and Ralph E. Flanders, who succeeded Mr. Hartness as president of the Jones & Lamson Machine Company. Mr. Hartness' concentration on his own machines was so great that he would not be diverted in his own work by the inventions and ideas of these younger men, but as they brought their ideas to him he freely gave them help and encouragement and was a factor in their success.

Though Springfield is a small country town, there has grown up there a large group of important tool-building plants, largely through his influence. In the last published *Membership List* of the A.S.M.E. there are listed more members of the Society from Springfield than there are from all the rest of the State of Vermont, and these members are without exception from the Jones & Lamson Company, or from other firms which have felt Mr. Hartness' influence.

Governor Hartness was one of the foremost mechanical engineers of this country and generation, and a splendid example of the engineer in public life. The Society holds him in affection and honor as an engineer and as a citizen.

—J. W. ROE.[1]

[1] Professor of Industrial Engineering, New York University, New York, N. Y., and author of "English and American Tool Builders," McGraw-Hill Book Co., 1926. Mem. A.S.M.E.

MECHANICAL ENGINEERING

Vol. 56 MARCH, 1934 No. 3

GEORGE A. STETSON, *Editor*

Henry W. Fowler

A BRIEF word of appreciation is an inadequate tribute to the genius of Henry W. Fowler, English scholar and lexicographer, recently deceased, whose book "Modern English Usage" has come so frequently and so effectively to the assistance of writers and editors. Henry W. Fowler had the rare and useful gift of combining authoritative scholarship with entertainment. Thus his book is picked up, by some at least, almost as frequently for the purpose of occupying an idle moment, in chuckling over a neatly worded comment lighted upon accidentally, as it is appealed to as an authority on usage. It thus serves a double purpose. Who would not, for example, be entertained as well as instructed by reading about the five classes into which the English-speaking world has been divided by the split infinitive? That Fowler's instructive and arresting style adds force to his purpose and drives deep into the memory his comment on certain usages, good and bad, is convincingly illustrated by the following example: " 'quite right' is all right, and 'all right' is quite right, but 'quite all right' is all quite wrong." His memory and his books are greatly cherished.

Correlating Creep Data

LAST month we printed a statement asking engineers to express their views on a proposed A.S.M.E.-A.S.T.M. correlated program of research on long-time creep tests (see pp. 127–128). This month we publish elsewhere in this issue a paper by P. G. McVetty on "Working Stresses for High-Temperature Service," in which the author suggests a plan of attack upon the store of undigested information relating to this pressing problem with the object of obtaining from it the greatest possible amount of use.

It has not been until comparatively recently that attention has been directed to the important and complex problem of the creep of metals under high temperatures and stresses. But with the growing use of materials that are subjected to high temperatures and high stresses, such as are found, for example, in modern boiler and turbine practise and in oil refineries and chemical plants, the designer is faced with a lack of knowledge of the behavior of the materials he wishes to use for the conditions under which the machine must operate. If he is conservative, his design is unnecessarily costly or even impossible; if he is overoptimistic, his machine or structure is liable to failure. If he waits until tests can be completed, he will be too old to worry about creep, his design will be no longer needed, or he will be forced to use a new material developed since the test began. For it is the time element, with his side-partner expense, that play the devils in the piece.

The very real problem that Mr. McVetty and others like him are trying to solve is how to predict the effects of stress on a material that is to be subjected to high temperature for a period, let us say, of several years, and further, how the data accumulated by numerous investigators can be translated into terms that the designer can rely upon when so many variables affect the experimental results.

Mr. McVetty confines himself in the present paper to the case in which stress and temperature are kept constant and deformation, or creep, is a function of time. In his attack on the problem he makes suggestions as to how creep curves may be extrapolated and how the available data may be correlated and reduced to a form convenient for comparison. It appears to be a highly useful piece of work, provided engineers will follow the suggestions or be stimulated to improve upon them.

In any event, the designer has a right to know, and it would seem that the engineering and metallurgical companies and engineers interested in this problem have an obligation not only to continue what they have been doing in the way of individual research but to see that all such work is properly correlated, with dependable data resulting for every designer's use.

Farm Mechanization

THE papers by Secretary Wallace and Mr. Flanders, presented elsewhere in this issue, recall to mind an excellent treatment of the effect of mechanization on wheat production by Leonard J. Fletcher before the World's Grain Exhibition and Conference, at Regina, Sask., Canada, last July, reported in the October, 1933, issue of *Agricultural Engineering*.

Mr. Fletcher points out that the labor requirements for producing 20 bushels of wheat per acre 100 years ago were 577 hr of work by man and 26 by horse, while, in 1930, 3.3 hr by man and 2 hr by tractor were required. However, in reducing these to proper energy equivalents, it is found that 265 units were expended 100 years ago as compared with 483 today.

Carrying the analysis further to a modern 500-acre wheat farm, Mr. Fletcher notes an equipment investment of $5000, with annual depreciation and obsolescence charges of $500 and operating costs of $750. Behind these items is the labor of many men, in other industries, representing, let us say, 2500 hr. Thus to the 1500 hr of labor per year expended by the farmer and his son, this other labor is added to make a total of, say, 4000 hr per year to produce the 500 acres of wheat.

The few number of males (1,015,000) engaged in agriculture in 1930 as compared with 1910 represents, as Mr. Fletcher points out, only an 8-per cent decrease in paid workers, while 92 per cent of the decrease has been

in unpaid family workers. Obviously, this reflects great social benefits.

Mechanization also has brought into production land which could not be handled by hand methods, and has made it possible to concentrate tillage, seeding, and harvesting in the relatively short periods most favorable for such work. Moreover, the sizes of farms have increased, the most efficient today being 2000 and 3000 acres or more, and this suggests the economies of collectivization of Soviet Russia.

But there are other considerations too. It has been shown that the cost of $79^1/_2$ cents per bushel on a half-section horse-operated farm is reduced to 51.1 cents on a three-section tractor-operated farm. Hence the margin of profit is affected by mechanization; and we find that the problem of marginal productivity is complicated by the problem of marginal mechanization.

The gains to the farmer are thus problematical, and the relationships vastly complicated. Almost every one has a solution to the farm problem but as yet none has worked. Unfortunately, more is needed than a spirit of optimism and good-will. Facts are stubborn things and an equation with an unlimited number of variables is hard to solve. It's best to get the facts and determine as many variables as possible before criticizing the solutions of others or offering some of our own.

Developing the Aeronautical Sciences

THERE has recently appeared the first number of the *Journal of the Aeronautical Sciences*, published by the Institute of Aeronautical Sciences, Inc., recently organized, with the cooperation of the American Institute of Physics, Inc. To the I.Ae.S. and to the editors of the new journal, heartiest greetings and the hope that they will serve the aeronautical sciences as ably as the character and reputations of their individual members and contributors promise.

None can predict to what lusty manhood an infant science may attain. It is human nature to doubt that primitive struggling industries will ever grow up. Indeed, many never do. And to accord serious attention to their technical and engineering problems when there is so much to be done in elaborating the technique and practise of established industries is not easy. Hence, in the past, the profession of engineering has permitted itself to be split up into highly specialized groups that ought to be more closely coordinated for their own sakes and for the sake of the profession—the strength that comes from unity, the benefits that come from close contacts in related fields of practise.

Fortunately, aeronautics has had such a strong appeal, both to laymen and to engineers, that it has been less of an orphan than some others have been. The early presidents of the A.S.M.E., particularly the first, Robert H. Thurston, were firmly convinced of the practicability of flying and made frequent mention of aeronautics as a field of engineering, unknown and unconquered, that lay ahead of mechanical engineers awaiting development. Nearly a quarter of a century later the Kitty Hawk flights vindicated Dr. Thurston's faith. In 1908, the A.S.M.E. held its first symposium on aeronautics. The War stimulated both the infant art of flying and the interest of the A.S.M.E. in it. And after the War that interest grew as engineers realized from the papers and meetings by A.S.M.E. groups that the aeronautical industry was introducing into engineering new principles of design, new ideals of workmanship, precision, and accuracy, new materials of construction, and new knowledge of aerodynamics and mechanics that had important effects on older practises in other fields of engineering. A new vigor, nursed into being by the strict discipline of a difficult task to perform, entered engineering with the development of aeronautics.

For several years past the A.S.M.E. Aeronautic Division has been actively pioneering in this new field of engineering, bringing into the consciousness of engineers of other lines the remarkable developments that workers in the aeronautical field have been developing. Numerous well-attended and enthusiastic meetings have been held from the Pacific Coast to the Atlantic, and dozens of technical papers have been added to the literature in the Society's Transactions and other publications. The most recent development of the Division, based on the realization that advances in aeronautics affect other branches of engineering, has been the reorganization of the Division's Executive Committee into a general committee including aeronautic experts and representatives of other divisions who are interested in what aeronautics has to offer them in the way of advanced engineering knowledge, and what they can contribute to it.

Members of the I.Ae.S. have been invited to meetings of the Aeronautics Division in the same spirit of friendly cooperation which has always marked that Division's zeal in trying to give as much as it can to others and get as much as it can from them in return for the benefit of aeronautics and mechanical engineering.

A Bureaucratic Reversal

LAST September it was announced (MECHANICAL ENGINEERING, September, 1933, p. 574) that arrangements were being made for the American Standards Association to take over from the U. S. Bureau of Standards the work being done by five of the divisions of the Bureau, including simplified practise and trade standards. It appears now, that, after much effort in good faith on the part of the American Standards Association in getting its affairs in shape to take over this work, the Department of Commerce has reversed its position and has decided to continue the simplified-practise and commercial-standards undertakings at the Bureau of Standards. This is a step in the wrong direction, and will be a keen disappointment to engineers who have long thought that such work can best be done by a non-governmental organization like the A.S.A.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

GERMAN STEAM AUTOMOBILES

TWO German locomotive companies, Henschel & Son, of Cassel, and A. Borsig of Berlin, have taken out licenses under the Doble patents for steam-driven automobiles. (For a description of the Doble car as first presented to the American public see MECHANICAL ENGINEERING, Vol. 39, No. 1, January, 1917, p. 90; and Vol. 43, No. 1, January, 1921, p. 50.)

The present article describes vehicles experimentally built by the former of the two licensees. One is a four-cylinder compound steam engine with an output of about 120 hp, the automobile developing speeds on tests up to 150 km (93.2 miles) per hr. It has been found that the consumption of fuel for a 100-km (62-mile) run at an average cruising speed of 70 km (43.5 miles) per hr is no longer greater than in an automobile of similar performance driven by a compression motor. As established by actual measurements, the car has a starting acceleration of 2.7 m (8.95 ft) per sec per sec. The supply of water is good for about 400 km (248.5 miles). The general arrangement of the car is shown diagrammatically in considerable detail in the original article. The evaporator consists of a single coil-wound tube made of several pieces by welding. It is located in an insulated jacket placed forward in the car. The feedwater inlet is at the bottom and the burner at the top so that the heat is transferred essentially in countercurrent. The exhaust gases are discharged into the atmosphere. The evaporator is provided with automatic regulation of the pressure and temperature of the steam which keeps the amount of steam evaporated at all times corresponding to the consumption. There is therefore no steam-storage provision made and the plant operates with only a very small supply of water, for example, 10 liters (2.64 gal) for a 80-hp car. Because of this, one can get a car going from cold in 2 min.

The steam is supplied by means of a foot-controlled valve through flexible piping to the engine located on the rear axle. The engine operates through a pinion directly on to a large toothed wheel enclosing the differential. The exhaust steam is led to the condenser located in the front of the hood and passes through two auxiliary turbines, one of which drives the combustion-chamber blower and the other the condenser deaerating pump. The water is practically completely recovered. Feeding of the evaporator is accomplished by a pump which may be built either as an independent steam-driven reciprocating piston pump or one driven from the rear axle of the vehicle. In addition to the 80-hp passenger automobile the company developed experimental drives for buses and trucks with capacities of 110 and 150 hp.

PRESSURE AND TEMPERATURE REGULATION

The pressure and temperature are regulated by instruments, the latter by a thermostat working through differential stretching of two elements, a steam contacted iron tube and a quartz rod. The pressure governor operates through a membrane. Both are shown in the original article. The process of regulation is as follows: Let it be assumed that at the beginning of a certain working period the pressure has reached its upper limit of 100 atm gage, under which conditions the temperature of the superheated steam is of the order of 450 C (842 F). If now, because of the demand on steam, the pressure falls off to the extent of, say, 10 atm, the pressure regulator acts to start the combustion once more. While the pressure was falling off the temperature fell off likewise, but when combustion is resumed the temperature begins to rise while the pressure may be still falling off. When the temperature again reaches the original 450 C the feedwater pump is started again by the thermostat, and, as the feed supply is resumed, the boiler pressure rises to 100 atm, whereupon both the feedwater pump and the combustion are stopped by the pressure regulator. If, however, for any reason whatsoever the temperature should go to about 470 C (878 F) before the pressure reaches the topmost permissible point, combustion is cut off by the thermostat, while the feedwater pump continues to operate. On the other hand, if the temperature does not come up the control is so arranged that the pump does not begin to operate. It is important to have a lower limit at which the pump is set into operation, as otherwise it might happen that on account of a delay in starting up combustion the evaporator would be oversupplied with water.

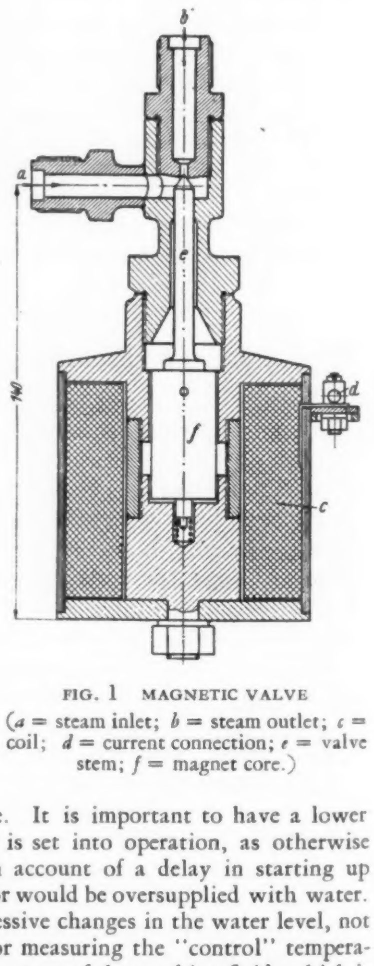


FIG. 1 MAGNETIC VALVE

(a = steam inlet; b = steam outlet; c = coil; d = current connection; e = valve stem; f = magnet core.)

In order to prevent excessive changes in the water level, not only is provision made for measuring the "control" temperature at the boiler end, but a part of the working fluid, which is a mixture of steam and water, is taken from the middle tube zone and after proper regulation is conveyed by a bypass pipe to the pipe coil just a little before the end thereof. By a correct combination of conditions determined by means of extensive tests, it is claimed that very good pressure and temperature regulation has been obtained. The impulses controlling the auxiliary machinery and control valves are operated by the opening and closing of current-conducting contacts in the regulator. When it is desired to cut the firing in the spark plug, fuel pump and blower motor receive current, while

the steam-driven feedwater pump is supplied with steam by means of a magnetic valve (Fig. 1). It may be mentioned here that the turbine driving the blower is provided with a spillway valve which bypasses the exhaust steam around this turbine when the control system shuts off the firing, while exhaust steam is still coming from the machine. This valve is also operated magnetically.

SPEED REGULATION

Because of automatic regulation of the boiler operation, it is not necessary for the driver to bother with watching the running of the steam-power plant. All that he needs to do to change the speed of the vehicle is to depress or release the foot-controlled accelerator. As the elasticity of operation of a steam engine eliminates speed-change gearing, the operation of the car is simplified and all that a driver needs to watch is the road. It is mentioned in this connection that a motor bus operating in a large city has to change gears some 4000 times a day.

Curves in the original article show the variation of torque of the engine with the velocity, while the curve shows the power output at the wheel. It is claimed that steam-driven vehicles possess the characteristics of rapid acceleration and hill-climbing ability, while tests in running these vehicles in large cities are claimed to show an increase of average velocity of travel of the order of 30 per cent.

The steam engine as a rule operates with inlet pressures considerably below 100 atm, this being controlled by the degree of opening of the foot-operated main throttle, as determined by the character of the road or the desired velocity of travel. In order to increase the tractive force in exceptional cases, throttle regulation permits a change in cut-off in the steam engine. By means of the foot accelerator the cut-off may be brought up to 80 per cent and returned without trouble to about 35 per cent which is mostly used. The same foot lever is operated to reverse the direction of travel, the arrangement being such that during the end period of forward travel the vehicle may be retarded by steam, and stopped, this being immediately followed by reverse acceleration. The reverse action of the steam-valve gearing gives, therefore, the possibility of additional effective braking.

Fig. 2, from the original article, is an example of the design of a two-cylinder compound steam bus engine with an output of 110 hp at 1500 rpm. An automatic receiver charging valve delivers throttled steam into the low-pressure cylinder at starting. The lubrication of the engine connecting rods is effected by dipping, while the oil to the steam cylinders is supplied by a pump. The steam engine is freely supported on the rear axle, an arrangement which was proved to be satisfactory as a result of long tests. The rear axle in addition carries the charging generator and the brake drum. It is stated that practically any liquid fuel can be used, and at present, for example, tests are being carried on with the idea of burning bituminous coal tar oil. The consumption of the fuel in buses and trucks per 100 km (62.1 miles) is about 30 per cent higher than in the case of a Diesel-driven vehicle. Thus, in cross-country operation and over hilly ground the consumption for a 5-ton truck or a bus with 40 to 45 passengers runs to about 50 liters (13.2 gal) of fuel oil. Nevertheless, because of its ability to handle cheaper fuels, the steam-driven vehicle shows several advantages from the point of view of cost of operation.

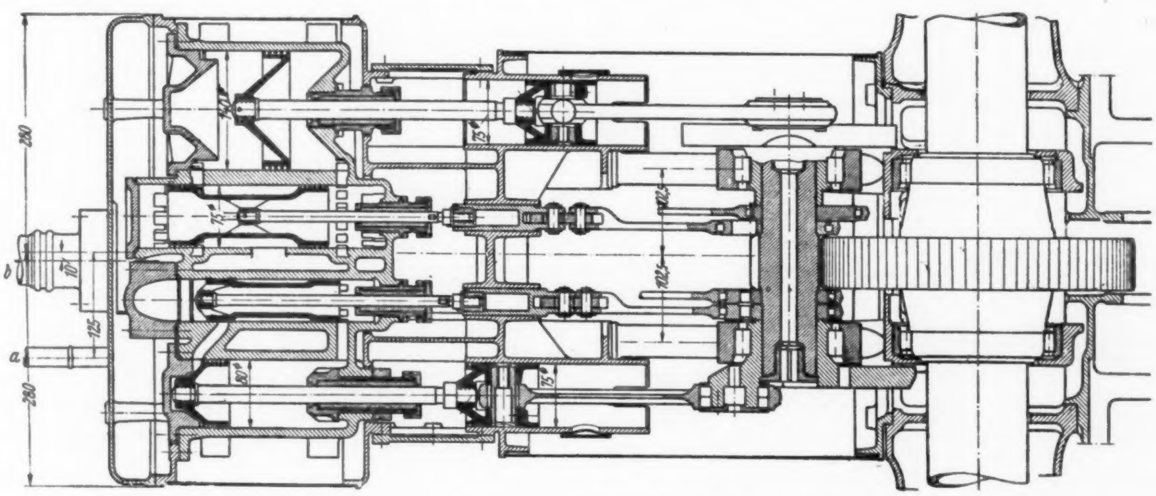


FIG. 2 TWO-CYLINDER COMPOUND STEAM ENGINE FOR BUS DRIVING, 110 HP OUTPUT AT 1500 RPM
(a = steam inlet; b = steam outlet.)

The condenser plant must condense up to 600 kg (1322 lb) of steam per hr and the fan drive requires an exhaust-steam pressure of about 0.5 atm. The warm air escapes from both sides of the hood. The advantage of this turbine-driven plant lies in the fact that it automatically adjusts itself to the demand for cooling air on the blower. Hitherto no attempt has been made to maintain a vacuum in the condenser. The weight of the plant has been kept so low that it is no heavier than the conventional Diesel-driven vehicle with 90 hp output. In the most recent design of the Henschel steam buses the power plant is located at the rear of the vehicle, which leads to a reduction in the length of the vehicle and length of piping and provides an ideal method of carrying off warm air and exhaust gases.

RAIL CARS

The German State Railways Corporation and the Lubeck-Büchen Railroad Corporation have become interested in the matter, both having ordered several units. In the original article is an illustration of a rail car built at the Cassel Works for the latter of the railroad companies. As this car is to operate at speeds up to 110 km (68 miles) per hr and as it must be capable of pulling trailers, the specifications called for an output of 300 hp at the periphery of the wheel. This output

corresponds approximately to 410 hp in the case of a Diesel-electric drive. As hitherto steam generating units of only 100 hp or thereabouts have been built, the jump to 300 hp in a plant as novel as this has been considered to be too risky, with the result that the steam-generating plant has been divided into two units, providing, incidentally, the possibility of operating it on one unit only in case of real necessity. Two steam generators have been provided, but only one steam engine, which operates on the wheel axle through a constant-ratio gear transmission. It is expected that in future units a single steam generator plant will be used, with a corresponding simplification of design. The car has been designed so that it could be operated either alone or as a pulling unit for a train. A corridor has been provided permitting passage from car to car when necessary or access to the baggage compartment.

The unit weighs 49 tons and provides seating capacity for 70 passengers. The general construction of the driving units is shown in Fig. 3, and the boiler in Fig. 4. The two steam generators are of the same design and entirely independent of each other, the heating surface amounting to 19 sq m (204 sq ft) per unit having been generously calculated with a view to providing for long-duration operation, such as might be required

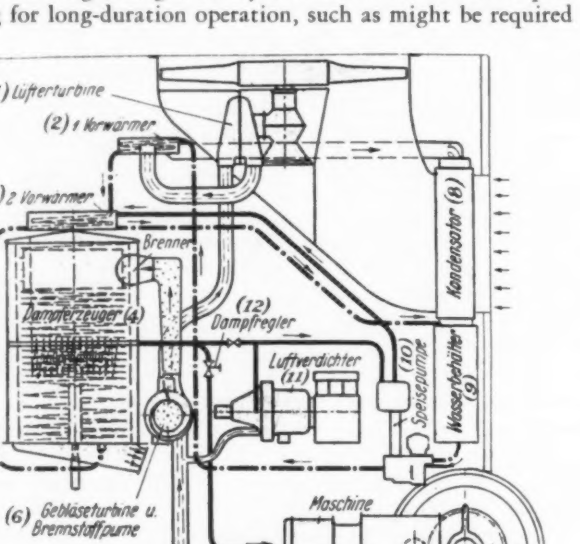


FIG. 3 DIAGRAMMATICAL SECTIONAL VIEW OF THE RAIL-CAR STEAM DRIVE

(1 = Fan drive for steam turbine; 2 = preheater no. 1; 3 = preheater no. 2; 4 = steam generator; 5 = lead to feedwater pump; 6 = fuel pump and turbine-driven atomizer blower; 7 = exhaust; 8 = condenser; 9 = water storage reservoir; 10 = feedwater pump; 11 = air compressor; 12 = steam regulator; 13 = live steam from boiler; 14 = exhaust; 15 = water going to boiler; 16 = heating steam; and 17 = combustion air.)

in the railroad business. The exhaust-gas temperature varies between 200 and 300 C (392 to 572 F). An effort has been made to maintain a constant steam temperature notwithstanding load variations and the curve in the original article is intended to show that this has been obtained.

It is shown that the temperature is maintained practically constant notwithstanding a sharp jump in load, first from 60 to 140 hp and then back to 30, all within a period of 6 min. The control pressure of the rail-car steam generator, that is, the pressure at which the pressure regulator cuts the auxiliary machinery out of operation, amounts to 80 atm. This steam pressure, however, reaches the cylinder of the steam engine only at starting, as the steam engine has been so proportioned that it can deliver the desired output while the car is running with a valve-chest pressure of 50 atm at most. Fig. 24 in the original article, not reproduced here, gives results of actual tests with 40 per cent cut-off and about 400 C (752 F) steam temperature, while another figure in the original article

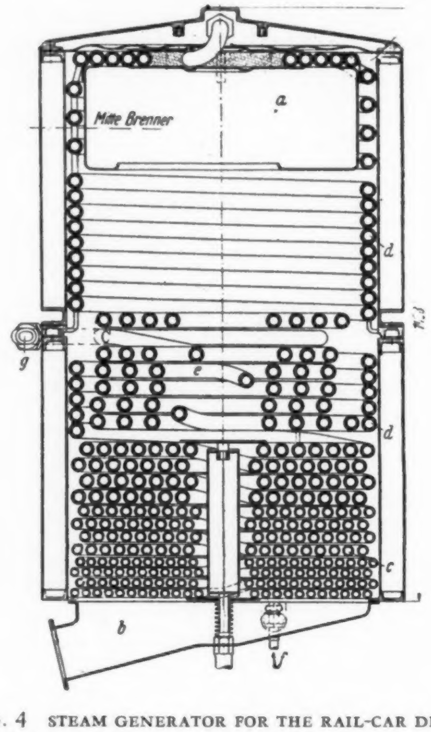


FIG. 4 STEAM GENERATOR FOR THE RAIL-CAR DRIVE

(*a* = combustion chamber; *b* = exhaust-gas passage; *c* = preheating zone; *d* = zone of evaporation; *e* = superheater; *f* = feedwater inlet; *g* = steam outlet; *mitte brenner* = mid burner.)

(Fig. 25, not reproduced here) gives the steam consumption which, in the case of such a small engine, is said to be low due to careful design.

The steam engine in this case was built as a two-cylinder compound unit with Stephenson gearing and piston valves. This gearing was used because it has the shortest length and on account of its simplicity offers advantages in manufacture and maintenance. The compounding as compared with a single-expansion machine has the advantage of smaller steam consumption, smoother tangential diagram, and materially lower mechanical stresses. Some details as to auxiliary machinery and the installation of the main machine are given and profusely illustrated in the original article. In addition to the installations described, an experimental 80-hp engine was installed on a motor boat. In this case the steam generator is arranged horizontally in order to reduce the height and make it possible to install it under the lower deck. The steam engine is a horizontal, two-cylinder, compound type driving the propeller shaft at 100 rpm and giving the boat a speed of 38 km (23.5 miles) per hr. Sea water is used for condensing the steam without any pump. (K. Imfeld and R. Roosen, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 78, no. 3, Jan. 30, 1934, pp. 65–74, 44 figs., *dA*)

Short Abstracts of the Month

APPLIED MECHANICS (See also Hydraulics: The Efficiency of a Water Turbine With Variable Head, Variable Dimensions, and Temperature of Water, but Running at the Same Specific Speed; Stresses in Stiffened Circular Tubes Under External Pressure)

Strength Tests of Thin-Walled Duralumin Cylinders in Compression

THIS report is the second of a series presenting the results of strength tests of thin-walled duralumin cylinders and truncated cones of circular and elliptic section. It contains the results obtained from compression tests on 45 thin-walled duralumin cylinders of circular section with ends clamped to rigid bulkheads. In addition to the tests on duralumin cylinders, there are included the results of numerous tests on rubber, celluloid, steel, and brass cylinders obtained from various sources.

The results of all tests are presented in non-dimensional form and are discussed in connection with existing theory. In the theoretical discussion, it is shown that the walls of a thin-walled cylinder in compression can be correlated with the buckling of flat plates under edge compression in an elastic medium, and that perhaps many solutions for problems in the buckling of plates can, with the proper factors, be applied to similar problems in the buckling of cylinders and curved sheets.

Wrinkling prior to failure does not apparently reduce the stress at failure.

For large fabricated cylinders, a change from welded to riveted seams has but little effect upon the stress at failure.

The compressive stress at failure is independent of the length so long as a certain ratio affecting the length of the cylinder making the cylinder very short is maintained. (Eugene E. Lundquist, National Advisory Committee for Aeronautics, Report No. 473, 1933, 20 pp., 10 figs., *tA*)

ELECTRICAL ENGINEERING

Electrical Transmission of Power by Means of Direct Current at Very High Voltages

THE difficulties and complication associated with the transmission of large blocks of electric power over considerable distances have led, during recent years, to a growing interest in the possible application for this purpose of direct current at high voltage. In spite of the fact that alternating current lends itself readily to generation and potential transformation in bulk, it cannot compete with direct current where transmisson on a similar scale is concerned. For this reason direct current can, under certain circumstances, form an economic link between the source of energy supply and the consumer.

The paper presents a broad survey of the basic problems involved in generating, transmitting, and transforming electrical energy in the form of supertension direct current as they appear at the present time, without attempting to add new matter to a subject which is of necessity highly specialized and lies in the province of the transmission engineer.

After a brief historical review of the subject has been given in the introduction, the manifold advantages of high-voltage direct current as a means of power transmission are discussed and the factors limiting its direct generation are investigated. Of the several methods available for converting alternating current or direct current at high voltages, relatively few are at once technically and commercially feasible. A general account is given of those current-converting systems which seem to offer the most promising solution to the transmission problem. The general trend of opinion in favor of the supertension direct-current system as reflected in modern transmission projects is explained, and an outline is given of three such schemes of major importance which have been put forward during the last few years. Finally, the paper indicates the course of a rational future development and suggests how the supertension direct-current system of power transmission might with advantage be introduced and further technical data obtained. (H. Rissik, before the Institution of Electrical Engineers, abstracted from preprint read in London, Jan. 18, 1934, 9 pp., including bibliography, illustrated, *d*)

Combined Single-Unit Converter and Motor

THE purpose of this construction is to provide a motor having an infinitely variable speed range and of such a character that it cannot be damaged by overload or improper use. To accomplish this a direct-current motor is combined in one frame with a single-armature rotary converter. By this construction the converter acts as a buffer between the supply system and the motor, and prevents overloads from being transmitted to the supply, while mechanical shocks to the motor and gearing are softened. Moreover, the motor runs in either direction and its speed is entirely under control so that when installed on a hoisting machine it can hold the load in mid-air without a brake. In other words, it has the operating characteristics of the throttle-controlled hoisting steam engine and no fuses to blow when overloaded. When lowering the load the function of the unit reverses and surplus energy is regenerated and used in the supply system. The motor can be stalled without damage, as the current will be reduced when the motor is stalled.

The original article shows diagrammatically the design of the motor and converter as well as the unit as incorporated in a winch design. The converter receives direct current from a source of fixed voltage and delivers variable current of variable voltage to the brushes on the motor. (*The Marine News*, vol. 20, no. 7, December, 1933, pp. 56–57, 3 figs., *d*)

ENGINEERING MATERIALS

Nikka Heat Insulation

THE Nikka insulation is applied to piping when cold, so that, unlike plastic insulation, it may be applied to a plant in operation. It is claimed that it gives a high degree of protection against heat losses, has a long life, and is low priced. The details of production of this insulation are not given. It is stated, however, that it is based on the use of Thermisol batting, which is a type of slag wool having its acid neutralized and generally purified. Tests made at the Research Institute for heat production in Munich have shown that it weighs 150 kg per cu m (9.30 lb per cu ft), this very low weight being due to the high degree of porosity of the material, the pores constituting 97 per cent of the volume. It is claimed that it is to the presence of fine air-filled cells that the coefficients of heat transmission for this material, obtained in the tests above referred to, are due, and with an average temperature in the insulating material of from 50 to 300 C (122 to 572 F), corresponding to a body temperature from 70 to 53 C (158 to

127 F). The coefficient of heat transfer varies according to a straight-line law within limits from 0.034 to 0.066 kcal per m per hr per deg C temp difference (1 kcal per m per hr per deg C temp difference = 7.2 Btu per ft per hr per deg F temp difference),[1] as illustrated in the original article by a curve. Up to a temperature of 800 C (1472 F) the Thermisol batting withstands both the temperature and volume effects. It is only at about 850 C (1562 F) that it begins to soften and at 1300 C (2372 F) it melts. It may therefore be used unrestrictedly for body temperatures up to 800 C without fear of disintegration. Its specific heat is of the order of 0.18 kcal per kg per deg C (0.18 Btu per lb per deg F). The extra heat losses due to storage of heat in the insulating material are therefore materially restricted in the case of Nikka insulation. Since the Thermisol batting is only loosely wound on the pipe, the expansion of the latter takes place without hindrance. On the other hand, however, care should be taken that the insulating material should not be made to expand and contract with the metal, as its coefficient of expansion is lower than that of iron. From this point of view the Nikka insulation has an advantage as against types of insulation which cling to the surface of the pipe and therefore have to follow the longitudinal expansion thereof, producing, at times, cracks in the insulation. To prevent penetration of moisture into the insulation the Nikka shell may be provided with a layer of moisture-proof material. In order to increase the mechanical strength of the insulation, as well as to produce an external hard jacket, the insulation may be covered by a mortar made of asbestos and infusorial earth with an addition of gypsum. A layer of jute constitutes an external covering. For pipe in buildings the insulation is finished by the application of one or several layers of varnish, while in piping laid in open air as well as in tunnels where there is a possibility of penetration of water, a tar-free cardboard is used for the external covering. The original article gives details of the application of this insulation as well as of the rings used to support it. The Nikka insulation is produced in two kinds and the original article gives the average coefficients of heat conductivity for various temperatures. (H. Lawall, in *Die Warme*, vol. 56, no. 49, Dec. 9, 1933, pp. 796–797, *d*)

FUELS AND FIRING (See also Internal-Combustion Engineering: Hydrogen Motor)

Experiences in Operating a Blower Driven by Sludge Gas

A GAS ENGINE using sludge gas as fuel to drive a blower has been installed at the activated sludge plant at Springfield, Ill. While it would be probably impossible to set down figures to show definitely the cost of this gas-engine operation, figures are given to show at least one measure of the results obtained and that is the fairly steady reduction in the amount of electric power consumed in supplying the compressed air to the aeration tanks. The construction cost chargeable directly against the gas engine was $7475. It is claimed that if the units continue to perform during the next four months as they have in the past nine months, the engine and heat-salvage units will have paid their way completely, and the savings would have been considerably greater had the information now available been at hand when the units were first designed.

The digestion tanks were formerly heated by means of a gas-fired boiler and are now heated by the waste engine heat. From this experience where the temperature of the sludge within the tanks has been permitted to go as high as 108 F, the author questions whether 80 F is the optimum temperature as has been ordinarily considered. The tanks have behaved well at 100 F and the supply of gas has been both steady and high in quality. The tanks have been operated in that way only for about three months, however, and no "control" tank for comparison of results exists. Higher temperatures, however, are now maintained in four tanks with waste heat than when formerly maintained in two tanks when the gas was burned under a boiler. The most important factor of this procedure has been the increase in heating-coil surface inside the tanks, necessitated by the attempt to salvage the engine heat. Some interesting data as to the transfer of heat into sewage sludge are given in the original article. A great deal remains to be known about the use of sewage-sludge gas for power, and whether or not it will be more widely used depends a great deal upon the care with which individual units are chosen for the next few installations, and the original article points out some of the factors to which attention must be given. (W. B. Walraven, Engr., Springfield Sanitary District, Springfield, Ill., in *Engineering News-Record*, vol. 112, no. 1, Jan. 4, 1934, p. 8, *d*)

HYDRAULICS

Stresses in Stiffened Circular Tubes Under External Pressure

THE strength of circular tubes under external pressure has been considered by various authors in the past, but the methods adopted are said not to have given results which can be used for purposes of practical design when dimensions are large and stiffening rings are of less than infinite rigidity. The usual treatment studies the elastic instability of perfectly circular tubes, rather than the stresses conformable to engineering practise; and circumferential stiffening rings or end conditions, if considered, are assumed to be of infinite stiffness. In short, the results cannot be interpreted in terms of thickness of plate, size of angle, stresses, and true factor of safety.

The author of the present paper recognizes that perfectly circular tubes, especially in large sizes, cannot be manufactured and he therefore includes this fact in his analysis. He recognizes that the stiffening rings, which are usually necessary, are not infinitely stiff and he therefore takes into account their yielding. The various possible forms of collapse, the spacing of stiffening rings, and the stresses developed are also considered.

The elastic conditions of the case are complicated and the analysis cannot be simple, but much of the work can be summarized in only two formulas, Equations [27] and [40] of the original article, which contain all an experienced designer is likely to need for daily use.

The author has applied these methods for many years to the design of internal risers for his differential surge tanks, and he feels that the principles of the paper may hence be considered to have been abundantly verified by full-size experiment. The same principles are also applicable to large penstocks under partial vacuum, to tunnel linings in soft ground, and other problems not infrequently encountered.

In an appendix a numerical example is given to assist in the understanding of the application of the formulas. Among other things, the author points out that engineers are not interested in knowing how great a pressure will certainly cause failure of an ideal shape but rather how great a pressure will certainly *not* create dangerous stresses in an actual practicable shape, and these two pressures bear no definite relation to one another.

[1] As the author does not specify the area to which his coefficient of heat transfer has been related, this factor has also been neglected in translating the metric value into fps units.

In order to arrive at the comprehension of stresses in circular tubes the author considers the matter of the deflection of and stresses in beams. This part is not suitable for abstracting.

One of the interesting parts of the paper is that dealing with nodes and the author shows that four and only four nodes need to be assumed. (Raymond D. Johnson, Mem. A.S.M.E., paper at the General Professional Meeting of the Engineering Institute of Canada, Montreal, P. Q., Feb. 8–9, 1934, abstracted through *The Engineering Journal*, vol. 17, no. 1, January, 1934, pp. 18–26, 3 figs., *mpA*)

The Efficiency of a Water Turbine With Variable Head, Variable Dimensions, and Temperature of Water, but Running at the Same Specific Speed

THE author shows how data of tests obtained in measuring the efficiency of a model turbine can be transferred to the design of a turbine of commercial size by the application of the principle of similarity. The present investigation deals with a comparison between the inertia and field forces, but completely neglects the effects of viscosity of the water.

A mechanical similarity between the full-size unit and the model exists if

$$\left(\frac{c_i}{\sqrt{2gH}}\right)_{\text{model}} = \left(\frac{c_i}{\sqrt{2gH}}\right)_{\text{full-size unit}} \qquad [1]$$

is satisfied. Here c_i denotes any arbitrarily selected velocity in the system of flow and H the head. It is assumed that the flow passages are geometrically similar. Neglecting the viscosity gives rise to certain discrepancies between the results of measurements on the model and those eventually obtained on the full-size unit. The influence of friction in model tests is likewise neglected, but should one desire to take it into account, it would be necessary to see that the Reynolds numbers at some arbitrary status be the same whether applying to the flow in the model or to that in a full-size machine, which means that R_e for the model equals R_e for the full-scale machine. On the basis of mechanical similarity, the Reynolds number can be defined, as follows: [2]

$$R_e = \frac{\sqrt{2gHD_1}}{\nu}; \quad \nu = \frac{\eta}{\rho} = \frac{\eta g}{\gamma} \qquad [3]$$

Here H denotes the head; g acceleration due to gravity; D_1 the entrance diameter of the tubine; ν the kinematic viscosity; η viscosity; and γ the specific weight of the water. The models, as a rule, are smaller than the full-size machines and care must be taken that, in accordance with the equation showing the equality of the Reynolds numbers, the head in the model is larger or the kinematic viscosity of the fluid used in the test of the model correspondingly smaller. It is only in the rarest cases that the condition of equality of the Reynolds numbers can be satisfied in model tests, and because of this, some other method must be resorted to.

Moody, A. Tenot, and Camerer, have established a relationship between the efficiency of the model and that of the full-scale unit, but their treatments are not sufficiently general.

The hydraulic efficiency of a turbine may be defined, as follows (neglecting the kinematic energy of inflow at the tail-water level):

$$\eta_h = \frac{H - c_3^2/2g - H_v}{H} \qquad [4]$$

where c_3 is the discharge velocity from the suction pipe, H_v is the so-called loss of head, which is defined as

$$H_v = \lambda \frac{L}{D}\frac{c_2}{2g} \qquad [5]$$

where

$$\lambda = \text{constant} \div \sqrt[4]{R_e} \qquad [6]$$

This relationship holds good for turbulent flow in straight pipes with circular cross-section. There is a certain amount of attraction in attempting to establish similar expressions for the magnitude of loss of pressure. In this case, however, in addition to losses due to friction against the walls, it would be necessary to consider also the losses in bends, which cannot be done in any simple manner. If we write

$$c \sim \sqrt{2gH} \qquad [7]$$

it is possible, because of similarity in the flow passages, to write Equations [5] and [6] in the following manner:

$$H_v = \frac{\text{constant}}{\sqrt[4]{R_e}} H = \frac{\text{constant}}{\sqrt[4]{\dfrac{D_1\sqrt{H}}{\nu}}} H \qquad [8]$$

If the expression for H_v from Equation [8] is inserted into Equation [4], this will give

$$\eta_h = \frac{H - c_3^2/2g - \dfrac{\text{constant}}{\sqrt[4]{\dfrac{D_1\sqrt{H}}{\nu}}} H}{H} \qquad [9]$$

and if we write

$$K_{c3} = \frac{c_3}{\sqrt{2gH}} \qquad [10]$$

we obtain

$$\eta_h = I - K^2_{c3} - \frac{\text{constant}}{\sqrt[4]{\dfrac{D_1\sqrt{H}}{\nu}}} \qquad [11]$$

In two similar turbines, that is, turbines of the same specific velocity, such as a model and a full-scale unit, where both operate under mechanically similar conditions, K_{c3} for the model = K_{c3} for the full-scale unit. Because of this it is not necessary to specify whether the magnitude K_{c3} applies to the model or to the turbine. Otherwise, hereafter, the magnitudes applying to the model will be designated by the subscript m and those applying to full-scale machines by the subscript a, which gives the following expressions:

$$\eta_{h_a} = I - K^2_{c3} - \frac{(\text{constant})_a}{\sqrt[4]{\dfrac{D_{1a}\sqrt{H_a}}{\nu_a}}} \qquad [12]$$

$$\eta_{h_m} = I - K^2_{c3} - \frac{(\text{constant})_m}{\sqrt[4]{\dfrac{D_{1m}\sqrt{H_m}}{\nu_m}}} \qquad [13]$$

It may be pointed out that because of the prevailing conditions of similarity the constants have the same values in both cases, and by eliminating them from Equations [12] and [13],

$$\eta_{h_a} = \psi(\eta_{h_m}) \qquad [14]$$

is found to be

$$\eta_{h_a} = (I - K^2{}_{c3}) - (I - K^2{}_{c3} - \eta_{h_m})\sqrt[4]{\frac{\nu_a}{\nu_m}\frac{D_{1m}}{D_{1a}}\sqrt{\frac{H_m}{H_a}}} \quad [15]$$

Since the overall efficiency is also of interest, Equation [15] may be given the following expression, remembering that $\eta_t = \eta_h \eta_{\text{mech}}$

$$\eta_{t_a} = \eta_{m_a}\left[(I - K^2{}_{c3}) - \left(I - K^2{}_{c3} - \frac{\eta_{t_m}}{\eta_{m_m}}\right)\sqrt[4]{\frac{\nu_a}{\nu_m}\frac{D_{1m}}{D_{1a}}\sqrt{\frac{H_m}{H_a}}}\right] \quad \text{........[17]}$$

where η_{m_a} represents the mechanical efficiency of the full-scale unit and η_{m_m} that of the model.

The author proceeds next to describe various tests carried out in order to prove the validity of Equation [17] and gives a curve showing results of these tests.

A good comparison between experiment and theory has been found. In addition to this a table gives values obtained by measurement as well as those obtained by calculations from the author's formula and the equations of Moody and Camerer.

On the whole, the present tests appear to have established the validity for the design of commercial units of results obtained on properly constructed models. (Dr. Engrg. R. Gregorig, Asst. Prof. of Machine Design in the Federal Technical University at Zurich, published in *Schweizerische Bauzeitung*, vol. 102, no. 15, Oct. 7, 1933, pp. 181–182, 1 fig., *etA*)

INTERNAL-COMBUSTION ENGINEERING (See also Fuels and Firing: Experiences in Operating a Blower Driven by Sludge Gas)

Rupa Coal Engine Test

IN A discussion of a paper on the charging of two-stroke engines, it was stated that in the Rupa engine (a Diesel-type engine fed with powdered coal) there was a supercharging effect, no mechanical means being required to compress additional air and without the necessity of having to distribute all the excess air into the combustion space and remove it again after part of its oxygen had been used. Actually, a mean effective pressure of 10 atm or more was easily obtainable in the Rupa engine. The diagram reproduced in Fig. 1, loaned by the inventor, was taken recently on the No. 7 Rupa motor, a single-cylinder four-cycle vertical engine of 140 bhp. The card indicates the unusually high mean pressures which could be obtained without any additional supercharging gear.

The governor at maximum charge was depressed by hand to the smallest point of firing, the mean pressure actually being 12.2 atm (173 lb per sq in.). Moreover, when one took into account the extreme flexibility offered in the range of fuels on which such an engine would operate, such as coal, brown-coal dust, charcoal, colloidal oil, vegetable refuse, and plantation offal, such as rice husks, olive roots, sawdust, etc., and that it would switch over from liquid to solid fuel (and vice versa) instantly without even stopping the engine, the possibilities offered by such an artificially highly supercharged prime mover would appear to deserve serious consideration.

In regard to this artificial supercharging effect, it was of interest to note that for every 1 kg of brown-coal dust introduced into the cylinder, 0.2 kg of fixed oxygen entered simultaneously, which obviously required no compression energy as would be the case when charging with what was really a great deal of superfluous air. One kilogram of brown-coal dust demanded only 4.8 cu m of cylinder air, while, without its inherent oxygen, this amount would require 6.93 cu m of cylinder air, or 1.45 times more. In other words, brown-coal dust would artificially supercharge the cylinders up to 45 per cent with air, which resulted in these fat diagrams—up to 15 atm at their thickest part.

With coal dust, mean pressures from 10 to 11 atm were obtainable, depending upon the inherent oxygen content of the coal which, he believed, ranged from 8 to 10.5 per cent in British coal and probably nearer the higher limit, or possibly up to 11 per cent in German coals. What would seem a most

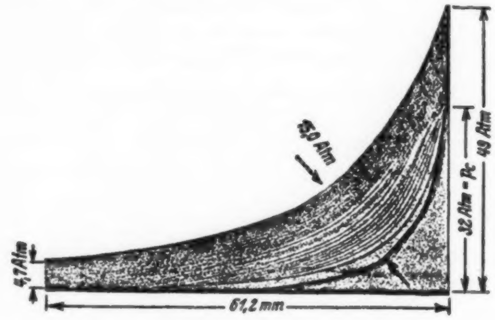


FIG. 1 INDICATOR-CARD DIAGRAM OF A SINGLE-CYLINDER FOUR-CYCLE VERTICAL RUPA ENGINE OF 140 BHP

important feature was that coal dust, as such, contained the right amount of oxygen in readily combustible state, just where it was wanted to promote perfect ignition and combustion of the fuel. It might be looked upon as a slow-burning gunpowder. Coal-dust injection would seem to hold out attractive possibilities when compared with supercharging methods, especially when the low cost of this home-produced fuel and its low consumption figures were taken into account. (W. Hamilton Martin, discussion before the Institute of Marine Engineers, abstracted through *The Marine News*, vol. 20, no. 7, December, 1933, pp. 67 and 70, *d*)

Hydrogen Motor

APART from the question of cost, hydrogen is a valuable fuel because both the gas and its products of combustion are non-poisonous and non-odorous. The possibilities of explosion with proper methods of handling are negligible. Any internal-combustion engine can be reconstructed to burn hydrogen without much trouble. Where, however, the compression ratio cannot be increased to 8:1, the output falls off to the extent of 3 to 5 per cent. A typical indicator diagram of a hydrogen-burning internal-combustion engine is given in Fig. 4. It was taken on an engine with a bore of 84 mm (3.30 in.) and a stroke of 110-mm (4.33 in.), running at 928 rpm and giving an indicated output of 3.09 hp and an effective output of 1.8 hp, the efficiency being 55 per cent. The fuel consumption was 0.6 cu m (21.18 cu ft) per hp-hr, and at a cost of hydrogen of 0.15 rm per cu m (0.1 cent per cu ft) the cost per horsepower-hour would be 0.09 rm (2.16 cents). It is claimed that under German conditions a horsepower-hour developed with gasoline would cost about 0.10 rm, so that in a 50-hp engine there would be a saving in the cost of fuel consumption of 0.50 rm (say, 12 cents).

The hydrogen-air engine can be operated by one of two processes. The first is similar to that of a gasoline engine, while the second approaches that of the Diesel process. The air of combustion alone is subjected to compression and the hydrogen is supplied at the upper dead center to an extent of

something like 333 cu cm (20.32 cu in.) per 1 liter of air (61.02 cu in.). In this way the cylinder is supplied with a mixture having a lower heating value H_u = 0.786 kcal per liter of cylinder content. (1 kcal = 3.968 Btu; 1 liter = 0.264 gal.)

In a gasoline engine the heating value of the mixture is 0.866 kcal per liter of cylinder content; but while the gasoline motor operates with a compression ratio of 4.5:1, the hydrogen motor has a compression ratio of 8:1. Because of this, in the matter of output per unit of cylinder volume, the gasoline motor is to the hydrogen motor as 1 is to 1.15. In practise this ratio of performance is even more in favor of the hydrogen motor, because, on account of the high compression ratio, the expansion line approaches the ideal or adiabatic line. Notwithstanding the extremely high temperature of combustion (1600 C ≐ 2912 F), the amount of heat transfer to the cooling water is less with the hydrogen motor than with a gasoline motor and whenever the gasoline motor has been rebuilt to burn hydrogen, it has been found that the output per unit of volume was increased. Because of this, it is not necessary to utilize completely the possible ratio of air to hydrogen, namely, 3:1.

The author discusses next the hydrogen-oxygen motor and points out that this motor is independent, in so far as its output is concerned, of the surrounding atmospheric conditions. It is, however, necessary to blow off the steam formed in the combustion. This makes the hydrogen-oxygen motor an ideal method of driving mine locomotives, submarines, and similar machinery.

Hydrogen can be also used to activate other fuels, such as alcohol, which are difficult to burn without some such activation. To show what may be expected from this the author quotes a test carried out on a standard 50-hp bus engine. When a very small amount of hydrogen was added to the charge the output of the engine increased 30 per cent, while the specific combustion of gasoline went down 50 per cent. Moreover, the flexibility of the engine increased greatly; for example, its lowest revolutions per minute were 220 with gasoline and 159 after the addition of the hydrogen. Similar results were obtained on a Diesel engine. (Gerhard Voss in *Archiv für Warmewirtschaft und Dampfkesselwesen*, vol. 14, no. 11, November, 1933, pp. 301–302, 3 figs., *d*)

The Scavenging of Two-Stroke-Cycle Diesel Engines

THIS article deals primarily with the practise of the Sulzer Company. The efficiency of a two-cycle Diesel engine depends to a great degree on the excellence of the scavenging, since bad scavenging gives a low mean indicated pressure, means great weight and high price per horsepower, and may bring about incomplete combustion and excessively high fuel consumption as well as lubricating-oil dilution.

The problem of scavenging a two-cycle engine is materially different from and more difficult to manage than that of a four-stroke-cycle engine. The earliest successful system of scavenging was developed as early as 1905 and like others of the systems is illustrated diagrammatically in the original article. In this system, the piston uncovered, at the end of the expansion stroke, a row of exhaust ports through which the products of combustion escaped. After the pressure in the cylinder had fallen to atmospheric, inlet valves arranged in the cylinder cover were opened, pre-compressed scavenging air entered the cylinder, and the scavenging began. After the gases remaining in the cylinder had been expelled and the exhaust port closed, the cylinder received a supplementary charge of air up to the scavenging-air pressure and then the inlet valves also closed. It was found, however, that dead spaces remained below the inlet valves during the scavenging process there and these were only partly cleared of the products of combustion.

About 1910 another arrangement was introduced. Here the cylinder cover contained only a centrally arranged fuel-injection valve which might be combined with the starting valve. Scavenging air flowed into the cylinder through inlet ports arranged opposite to the exhaust ports. In this way "after-charging" was introduced, allowing the cylinder to be charged at the beginning of the compression stroke with a greater quantity of air than could be introduced into the cylinder of an ordinary two-stroke-cycle engine of the same dimensions without requiring additional work. Furthermore, the piston was permitted to retain its symmetrical proportions and the

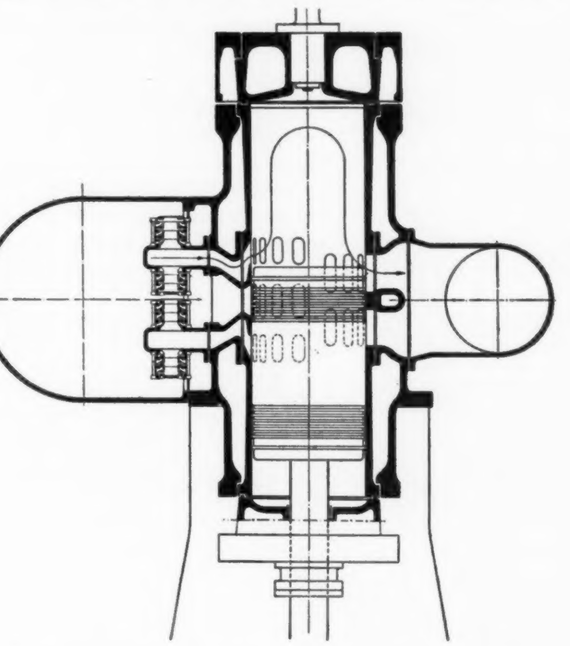


FIG. 2 SECTION THROUGH THE CYLINDER OF A TWO-STROKE DOUBLE-ACTING ENGINE WITH SULZER SCAVENGING

cover has been considerably simplified, this latter feature making it possible to produce cylinders of large bore up to 1000 mm (39.37 in.), quite reliable in service.

In the next development of this method of scavenging the positively controlled double-beat valve was replaced by a row of automatic valves, increasing the simplification and reliability of the engine. For engines intended to take care of peak loads in electricity works, the scavenging process with supercharging was developed. The first part of the process is the same as before, but after the cylinder has been charged with air up to the scavenging-air pressure, a positively controlled valve opens and compressed air flows into the cylinder through the upper row of ports. This valve admits only the quantity of additional air required for supercharging. This supercharging air is generally supplied by a low-pressure compressor arranged over the scavenging pump and driven from it. The compressor can be throttled when not required and then runs light.

In the Sulzer scavenging process for double-acting Diesel engines three rows of ports are provided, one above the other (Fig. 2). The middle row is permanently connected to the scavenging-air receiver, while the two outer rows are controlled by automatic valves. In certain cases the middle row of inlet ports may be omitted, while special circumstances may make it advisable to arrange the superimposed inlet ports

directed backward, as shown in Fig. 3, instead of radially. The most favorable slope for the inlet ports with respect to the cylinder axis must be determined for each particular case and cannot be governed by a general rule.

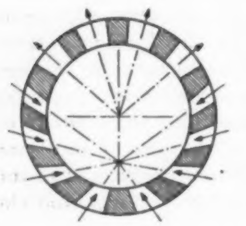


FIG. 3 SECTION THROUGH A CYLINDER WITH TANGENTIAL BACKWARD SLOPING PORTS

In general, the scavenging effect may be improved by lengthening the scavenging-air piping and utilizing the kinetic energy of the air to increase the charge in the cylinder. This construction has the drawback that a fixed scavenging-air pipe is only effective when the engine is running at a certain speed; also it takes up too much room. A good scavenging effect can also be obtained by "uniflow" scavenging where the scavenging air enters the cylinder at one end and the exhaust gases leave it at the other.

Two cylinders may give quite different outputs, although they are apparently exactly similar. The reason for this may be ascribed first of all to the fuel-injection device, or to leakage past the piston rings, or to pressure waves in the scavenging air or exhaust piping. It may, however, be found that in spite of careful adjustment of all these members and of the pressure variations, and even after the injection valves and the pistons have been interchanged, the outputs obtained still remain unequal. The reason for this is evidently some anomaly in the scavenging.

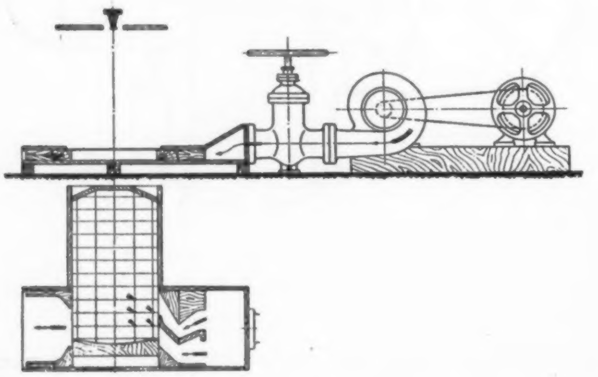


FIG. 4 APPARATUS FOR THE EXPERIMENTS ON TWO-DIMENSION SCAVENGING FLOW

The explanation of the irregularity is given at once by investigating the flow of the scavenging air, i.e., of the path taken by the scavenging air in the cylinder. For this purpose the apparatus shown in Fig. 4 is used. It shows the direction of flow of the scavenging air in two dimensions in a plane containing the axis of the cylinder. For introducing the scavenging air, passages are provided of a profile similar to the scavenging air ports in the engine. The scavenging process takes place between two parallel level surfaces, about 60 mm (2.4 in.) apart, the upper one being made of thick plate glass. The scavenging space is bounded at the side by four walls, corresponding to the sections through the cylinder cover, liner, and piston. The scavenging air escapes through an opening corresponding to the exhaust ports. A complete picture of the flow of the air is obtained by a number of small pieces of light silk distributed over the cross-section of the cylinder. (Figs. 5 and 6.)

When the profile of the scavenging air ports is changed, the type of air flow naturally changes also. Nevertheless, two main types of flow may be distinguished, the first of which (designated "normal flow" in the following discussion) is characterized by the scavenging air's flowing direct from the inlet ports to the cylinder cover (Fig. 5). In the second type of flow, here termed "reverse flow," the scavenging air flows straight across the cylinder, over the piston, and only then up along the opposite wall toward the cylinder cover (Fig. 6). In this case, a certain quantity of scavenging air is lost, since some of it escapes through the exhaust ports without taking part in the scavenging. This causes whirls in the upper and the lower part of the cylinder, the latter being then only partly scavenged.

A surprising feature of these flow diagrams is the number of port profiles which cause unstable flow of the scavenging air. This instability, which appears to be normal, is shown by a sudden reversal of flow, and then, just as unexpectedly, a reverting to its original form.

But even this instability is not always consistent, for if a copy is made of such a port profile and used in place of it, the resulting flow may be always a stable reverse flow. The next copy made may, in certain circumstances, give always a stable normal flow. This explains to some extent the difference in output of two cylinders which are apparently exactly similar.

For investigating more accurately the conditions of steady flow of the scavenging air, recourse has been had to a model of an actual cylinder described in detail. Here a new phenomenon has appeared. Normal scavenging, even when stable, may have powerful rotary components, this being a feature possessed to a greater or less degree by all streams of scavenging air in the model cylinder when the air currents flowing out from all the scavenging ports are directed against a common axis. The article discusses the factors affecting the angular velocity of the scavenging flow. At a certain position of the piston, which might be described as the critical piston height, the normal scavenging changes over to reverse scavenging. This is discussed in detail and illustrated in the original article.

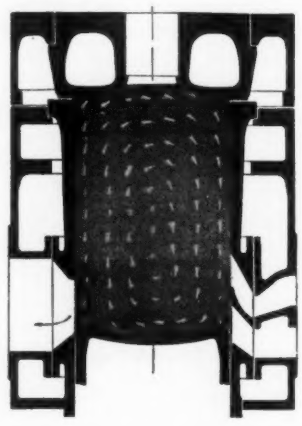


FIG. 5 NORMAL SCAVENGING

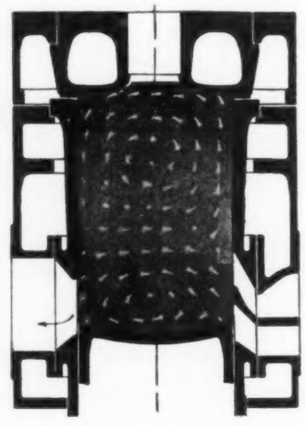


FIG. 6 REVERSE SCAVENGING

The author's conclusion is that, in engines with inlet and exhaust ports situated opposite each other, it is best, whenever possible, to endeavor to obtain normal scavenging. The author discusses the influence of the size and direction of the cross-sections of the ports uncovered by the piston during the scavenging process, as well as the methods by which their influence has been determined experimentally. The influence of the temperature of the air is also discussed. (Bl., *Sulzer Technical Review*, 1933, no. 4, pp. 1-11, 26 figs., *dh*)

Bagnulo Carburetor and Cylinder Head

A DESCRIPTION of the Bagnulo carburetor and cylinder head by means of which any high- or low-speed engine may be adapted to operate equally well on gasoline, alcohol, gas oil, vegetable oils, etc. The essential feature of the head is the mixer or antechamber. This is a heavy-walled, spherical chamber insulated by an air space from the cylinder head proper, in which the fuel is gasified at a constant temperature without excess of air. The combustion air is not admitted until just before the end of the stroke. A spark plug fires the charge in the usual manner. All that is required when changing from one kind of fuel to another is simply a change in the adjustments. It is claimed that excellent results have been obtained with all the fuels under actual road conditions. (*Omnia* (France), December, 1933, pp. 409–410, 2 figs. Abstracted through *Automotive Abstracts*, vol. 12, no. 1, January, 1934, p. 12, *d*)

The Cross Rotary Valve

THIS valve, invented by R. C. Cross, is claimed to function perfectly at speeds up to 10,000 rpm. Its essential feature consists of utilizing the spring of the high-tensile phosphor-bronze sleeve to secure gas-tightness between the sleeve and the valve. The edges of the sleeve surrounding the rectangular part project beyond the supporting surfaces of the casting and are tapered. The construction causes them to spring slightly toward the rotating valve and to make a firm contact therewith.

An extremely hard metal is used for the valves which are said to be almost unwearable. It is claimed that the absence of hot valve heads permits higher compression ratios to be used without producing detonation. It is said that these valves have been used in motor-cycle engines operating with ordinary gasoline-benzol fuel and utilizing compression pressures of about 300 lb. Power, as shown by the Heenan-Froude dynamometer, is said to have reached 68 bhp per liter (1 liter = 61.0 cu in.) capacity without supercharging, and a brake mean effective pressure of 163 lb per sq in. at 4400 rpm is claimed. (The *Commercial Motor*, vol. 58, no. 1500, December 15, 1933, p. 680, 1 fig. Compare also *Automotive Abstracts*, vol. 12, no. 1, January, 1934, pp. 10–11, *d*)

LUBRICATION

Refining of Mineral Oils

THE author deals with insulating oils in switches and transformers as well as lubricating oils used in the operation of turbines and automotive vehicles. Only the latter part will be considered here. It is pointed out that even if the cost of rerefined oils were no lower than the cost of new oils it would have been worth using rerefined oils in Germany, providing the results were satisfactory, as new oils have to be imported from abroad, while the cost of rerefining would be consumed at home. Actually, it is pointed out, rerefined oils cost less and have given satisfactory performance.

As to the methods of rerefining it is stated that oil is first submitted to heating by means of superheated steam to drive off the dilution of lighter fractions. The sludge is next precipitated by a sulphuric-acid treatment, whereupon the oil receives a clay treatment, followed by some kind of filtering. As to tests, it has been found that laboratory tests do not give sufficiently reliable information as to the lubricity of oils when used in actual service. The authors therefore relied exclusively on practical runs made apparently under their observation at the Berlin Municipal Electricity Company's plant. It was used in a turbine for a period of about 8000 hr of actual operation from 1928 to 1931, at which time the turbine was put out of commission. The performance of the oil was entirely satisfactory, and in 1931 rerefined oil was put into two turbines in another plant of the same company.

The results are presented in the form of curves which show that substantially the two oils—the new oil and the rerefined oil—behaved in approximately the same manner. The performance of rerefined oil in motor vehicles has been observed in cars belonging to the same company and operated on rerefined oil since 1931. It has been so satisfactory that the authors came to the conclusion that rerefined oil can be safely used in important machinery of the largest size.

Two tables are given in the original article—one containing a comparison of properties of new and rerefined oils including viscosity-temperature index information, and the second table giving the comparison of performance of new and rerefined oils on transformers. (Dr. of Engrg. H. Richter and A. Ruppelt, Communication from the Lubrication Office of the Berlin Municipal Electricity Company (BEWAG), abstracted through *Elektrizitatswirtschaft*, vol. 32, no. 23, Nov. 30, 1933, pp. 497–500, 3 figs., *p*)

Railroad-Car-Journal Oils Tested Under Severe Conditions of Temperature Change and Load

THE problem of railroad-car-journal lubrication is an enormously difficult one because of varying conditions under which the apparatus has to operate with the same oil, as may be illustrated by the case of a car which, in the depth of winter, travels from, say, the summer atmosphere of Florida to 40 or so below zero in northern Canada. In the present case the author tested several series of oils, first by means of a waste-grab tester to establish the relation between waste-grab torque, viscosity, and temperature, using A.R.A. specification car oils as such or with dopes. The tests confirmed the previous observations of C. T. Ripley and Chapman of the Atchison, Topeka & Santa Fe Railway to the effect that viscosity alone cannot be used as an index to waste-grab tendency. It was also found that various oils react differently.

The next series of tests was carried out on the Sinclair extreme-pressure test machine described fully in the original article. Using the same load the stable temperature rise was taken as indicative of the lubricating qualities of the oil under test, the temperature being the main limiting factor in the carrying of high unit bearing pressures.

The series of A.R.A. car oils as used in the waste-grab tests was investigated to determine their load-carrying capacities by means of a Sinclair extreme-pressure test machine, the results being given in the original article in the form of three-dimensional curves.

For an equivalent viscosity the summer oil carried a greater load per square inch than did the winter oil, and again it was found that the viscosity at the operating temperature is not the determining factor as to load-carrying capacity.

The adhesion factor of oils was next investigated on a Sperry-Cammen oil testing machine, correlated by the author in cooperation with the Sperry engineers with his own data on the A.R.A. and Cuban Railroad car oils, which the author had evaluated according to their performance in actual service. The machine and test procedure are described in the original article. The machine measures the adhesiveness of the lubricant with respect to the particular metal of which the rotor band forming part of the machine is made. In general, it has

been found that the grading of oils by the amount retained on the rotor under various conditions coincides with the service record. A check of the adhesion performance was made for the Pennsylvania extra-heavy zero-pour oil and the Gulf Coast extra-heavy zero-pour oil, the waste-grab performance of which is shown in another chart. Although these oils are of the same viscosity at 210 F, the Pennsylvania oil carried a load up to 2800 lb at 260 F, while the Gulf Coast oil failed at 1900 lb at 200 F.

The chart in the original article shows that the Gulf Coast oil loses its adhesiveness with increase in temperature faster than the Pennsylvania oil. Yet at low temperature the adhesiveness of the Gulf Coast oil is the greater. It is concluded that what is needed is not only a low rate of change in viscosity with temperature (viscosity index) but a low rate of change of adhesion with temperature (adhesion index). (C. M. Larson, Sinclair Refining Co., paper delivered before the A.S.M.E. Annual Meeting 1933, abstracted through *The Oil and Gas Journal*, vol. 32, no. 30, Dec. 14, 1933, pp. 15–16 and 18, 7 figs., *e*)

MACHINE TOOLS

Progress in German Machine Tools

IN ORDER to prevent vibration, the working components of machine tools must be very carefully balanced. For this reason, all parts rotating at high speeds are finished all over. Every good machine-tool plant is today equipped with balancing machines. These machines not only balance the various individual component parts, but also the entire spindle-head unit, in order to eliminate any trace of unbalance such as might possibly have been introduced during assembly.

The principal difficulty used to reside in the design of bearings adapted to the new high speeds. For quite some time, and as exemplified by grinders, it has been possible to build bearings which can successfully stand high speeds as long as no heavy loads occur at the same time. In present-day internal grinders, speeds up to 54,000 rpm are attained, and for such speeds surface bearings and anti-friction bearings alike are suitable and both have proved satisfactory for finishing machines. In high-duty machines which must take heavy cutting forces in addition to high speeds, however, such bearings would run hot because of edge pressure. In machines of this kind, the trend of late years has been to make the spindle extremely resistant to deflection and use only a single roller-bearing at either end. In order to secure maximum accuracy, the bearing inner rings are mounted on the spindle and finish-ground together with it in the same operation, Fig. 7.

Especially where high speeds are concerned, wear is limited by widening the guiding surfaces over former practise and thereby reducing surface pressures. This increase in width is rendered feasible by the fact that such guiding surfaces today can be produced by grinding and without resort to expensive scraping operations. The difficulties which beset ways grinding when it was first introduced are today definitely overcome.

In an effort to perfect operating qualities, special attention has been devoted to a number of things previously considered non-essential. Dependability of operation is largely a matter of the design of the lubricating means. With the exception of small machines, machine tools today are universally equipped with automatic lubrication. In its simplest form, this consists in immersion, whereby one or more wheels in running dip into the oil sump of the spindle box and fling oil to all lubricating points. This method of lubrication is applied only with surface speeds low enough to prevent undue atomization of the oil and heating of the spindle head. As a rule, special oil pumps with short, wide tubes leading to the different lubricating points are provided, together with safety devices intended to bring about stoppage of the machine in the event of failure of the lubrication. Among these devices are inspection covers and windows in spindle boxes, while with large and costly machines, automatic safety-appliances are provided whereby the machine is locked against running when the oil-pump is not functioning. Protective devices for guarding against overload are built into machines as a matter of course.

Particular care has been bestowed of late years upon the design of the manual controls. A leading demand today is that gears must be capable of being conveniently and rapidly engaged and disengaged. The complicated combination tables once generally found on spindle boxes are more and more being discarded. Instead, the speeds or feeds set are numerically indicated behind windows, and every effort is made to get along with the smallest possible number of control levers.

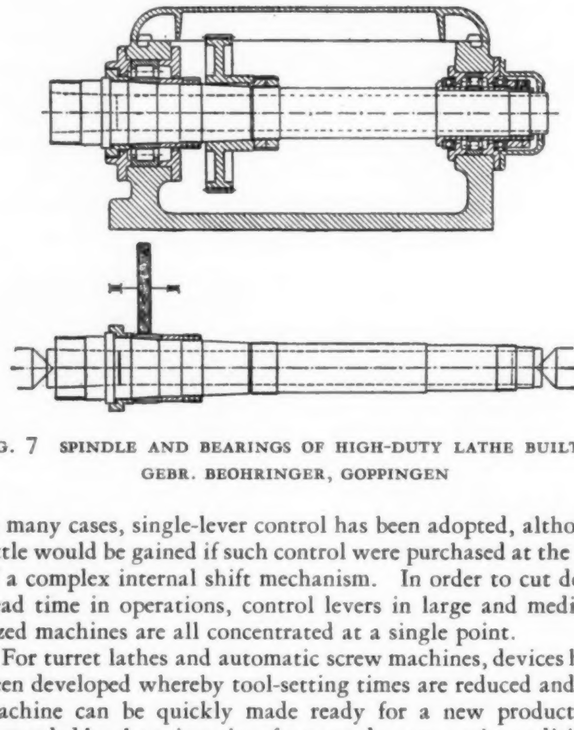


FIG. 7 SPINDLE AND BEARINGS OF HIGH-DUTY LATHE BUILT BY GEBR. BEOHRINGER, GOPPINGEN

In many cases, single-lever control has been adopted, although little would be gained if such control were purchased at the cost of a complex internal shift mechanism. In order to cut down dead time in operations, control levers in large and medium-sized machines are all concentrated at a single point.

For turret lathes and automatic screw machines, devices have been developed whereby tool-setting times are reduced and the machine can be quickly made ready for a new product, as demanded by the exigencies of present-day economic conditions. In drum-type turrets, the tool carrier with the entire tooling set-up can be exchanged. By varying the speed of rotation of the control cams or the instant of lift of the followers, the time-consuming exchange of cams is largely avoided. As elsewhere in modern single-purpose machines, the speeds in these tools are varied by means of quickly interchangeable change gears.

In the German machine-tool industry, standardization of working speeds has been uniformly introduced. There exists no good German machine tool in which the spindle does not run in accordance with the standardized speeds. Among other advantages, the general employment of these standard speeds greatly simplifies the work of estimating.

The possibility of attaining the high speeds favorable for a fine finish by the use of tungsten-carbide or diamond cutters has resulted in the introduction of a new group of tools, the precision-finishing machines. There are precision-finishing lathes for external work, and precision-finishing drills for

internal operations. These machines work with a single cutter, and at their first appearance served for finishing operations on materials difficult to grind, such as elektron and copper. From these initial purposes, their use has been extended to final operations on other machines, so that today the process is in competition with honing and finish reaming. Late machines of this kind are of extraordinarily rigid design and differ from their prototypes in the possession of special devices for insuring high precision. The quill is guided in special bearings and is entirely separate from the drill spindle proper, which is charged only with the drive. The bearings are equipped for cooling to prevent inaccuracies due to the generation of heat. Cutting speeds range up to and over 100 m (330 ft) per min with steel and cast iron and 500 m (1600 ft) per min with light metal. Feeds throughout are fine, attaining figures as low as 0.01 mm (0.0005 in.) per revolution and under. (Dr. H. Kiekebusch, Berlin, *Engineering Progress*, vol. 14, no. 12, December, 1933, pp. 235–238, *dg*)

MARINE ENGINEERING (See also Power-Plant Engineering: Tests on a Johnson Water-Tube Boiler)

Brown Boveri Marine Turbloc Machinery

IT IS claimed that with this arrangement remarkable savings in fuel, machinery weight, and space occupied are attained. A feature of the plant is the driving of most of the auxiliaries off the main "turbloc" unit. The turbloc can be operated with Scotch or water-tube boilers fitted with superheaters, and has been designed primarily for the ordinary cargo ship and the fast cargo liner, being suitable for outputs between 1800 and 10,000 shp on a single screw. The larger installations are, however, obtained by doubling the first gear train and the number of turbines. In an installation shown as designed for 2000 shp at 75 rpm, one high-pressure and one low-pressure turbine casing working in series are provided, the turbines being of the small high-speed type but of moderate circumferential speeds. Each turbine is coupled to an independent pinion and runs at its most suitable speed for efficiency. Thus the high-pressure rotor runs at 6000 to 6500 rpm, and the low-pressure turbine is placed high enough to allow the use of a condenser of the "underfitted" type directly beneath it and to give a sufficient head for the injector of the condensate pump but not high enough to cause the propeller shaft to be unduly raised. A brief description of the turbines is given in the original article.

The distribution of the output between the high-pressure and low-pressure turbines is in the same ratio as the diameters of the pinion, so that under normal conditions the high-pressure turbine provides 45 per cent and the low-pressure unit 55 per cent of the total output. This power distribution makes it possible to locate the entire astern turbine in the low-pressure cylinder without overloading the low-pressure pinion when the full astern output is developed.

For overload purposes an additional bank of nozzles with hand-operated valve is provided in the high-pressure turbine. Not counting the consumption of the auxiliaries and using steam superheated to 750 F with a pressure of 285 lb per sq in. gage and a vacuum of $28^1/_2$ in., the steam consumption of the turbloc installation described is about 7.9 lb per shp-hr, and in the larger sizes this figure is reduced to about 7 lb per shp-hr. The weight of the turbloc for an output of 2000 shp at 75 rpm (screw) including all auxiliaries is between 40 and 45 tons.

So far as the operation of auxiliaries during maneuvering is concerned, the impeller of the circulating pump is so designed as to give an output of about 60 per cent when the turbines are running in the reverse direction, which is ample for ordinary conditions. This arrangement is already in use in the turbine-driven Rhine tug *Dordrecht*, engined by Brown Boveri & Co., Ltd., and has given complete satisfaction. It will be appreciated that in this class of vessel, maneuvering forms a large proportion of the engine service.

A table in the original article gives comparative figures for the propelling plants of various types of 2000 shaft hp and 75 rpm. This comparison has been drawn up by the engineers of the Brown Boveri company. The total fuel consumption in pounds per shaft horsepower per hour is given for a reciprocating engine, Scotch boilers, and oil fuel as 1.03. For a reciprocating engine with exhaust-steam turbine, oil fuel, and Scotch boiler, the fuel consumption is 0.825 lb per shp-hr, for the Brown Boveri turbloc, oil fuel, and Scotch boiler, it is 0.67, and with Velox boiler, 0.622 lb per shp-hr. (*The Marine Engineer*, vol. 56, no. 675, December, 1933, pp. 353–357, illustrated, *d*)

Vulcanized Gum Lining of Propeller Shafts

TO PROTECT the propeller shaft from sea-water corrosion in the twin-screw steamer *Soya Maru*, the ice-breaking ferry of the Imperial Government Railways, a process of vulcanized gum lining of the shaft was employed at the Yokohama Dock Yard. After some six months of service the steamer docked and it was found that the lining gave satisfactory protection. It is claimed that with this method there is a saving in weight and reduction in expense. (T. Morisawa, Proceedings of the Joint Meeting of Zosen Kiokai and Hanshin Club, Journal of the Society of Naval Architects of Japan, vol. 52, October, 1933, pp. 67–78, 2 pages of drawings, in Japanese, *d*)

Pulverized-Coal Burning in Marine Boilers

THE articles apparently do not contain any new information and is written in the Japanese language, except for the tables which are given in English. It is these tables that are of interest, as they represent practise on pulverized-coal burning collected during the author's inspection trip through Europe and contain the material tabulated in a convenient form. It gives also in the form of tables trial results of several types of installations, such as the steamship, *Berwindlea*, *Donau*, and the Brand system on Scotch marine boilers. Some of these test data, however, have been previously published elsewhere.

The article describes and illustrates in detail the Clarke Chapman Resolutor pulverizer as installed in recently built steamers *Johore Maru* and *Nagoya Maru* of the Ishihara Industrial and Transport Co., Ltd. (Matsugoro Hirata, Proceedings of the Joint Meeting of Zosen Kiokai and Hanshin Club, Journal of the Society of Naval Architects of Japan, vol. 52, October, 1933, pp. 79–111, illustrated, partly in Japanese and partly in English, *dg*)

Multiple-Engine Marine Diesel Drive

IN A RECENT Thomas Lowe Gray Lecture before the members of the Institution of Mechanical Engineers, H. R. Ricardo outlined a marine scheme for installing 75 high-speed Diesel-electric sets, each of 100 bhp, in a vessel requiring 5000 shp. The extra power is provided for ship's use and reserve.

Mr. Ricardo in the concluding portion of the lecture referred to his "dream" of multiple-engine installation and also made comparisons between monster Diesel engines of today and the

prehistoric monsters in the National History Museum. The lecture embodies figures for capital and operating costs, allowing for an engine of very low rating, so that reliability and maintenance should be even better than with the engines upon which the estimates are made. (Abstracted through *The Internal Combustion Engineer*, vol. 1, no. 3, January, 1934, pp. 65–66, *g*)

MUNITIONS

A New Light Machine Gun

THE decision of the Indian Army Authorities to re-arm the cavalry with the Vickers-Berthier light machine gun suggests that this new weapon, which has undergone, and is still undergoing, War Office tests, will, in the future, be an important arm of the British Services. It is simple in construction, easy to manipulate, and weighs only 10 kg, complete with its bipod fitting, and 23 kg with a tripod. It combines in one weapon the functions of the light automatic gun carried and fired by one man, and those of the heavy-rifle-caliber machine gun. When used as a light weapon, it is generally fired from the bipod, or from the shoulder or hip, the tripod fitting being reserved for the heavier machine-gun duties. The ammunition is contained in a sector-shaped magazine, which is quickly clipped to the gun and carries 30 rounds. A change of magazine takes only two seconds, while only eight seconds are needed to replace a barrel. By the movement of a lever near the trigger, the gun can be used either as an automatic weapon, or for deliberate single shots. It can be employed to fire 300 rounds in a minute, which time includes the changing of magazines, and for deliberate firing a trained man can make up to 90 aimed shots in a minute. (*The Engineer*, vol. 157, no. 4071, Jan. 19, 1934, p. 61, *d*)

POWER-PLANT ENGINEERING

Radiant-Heat Boilers at Brimsdown

THE Brimsdown "B" Power Station of the North Metropolitan Electric Supply Co., of London, is said to represent the most recent stage in the development of pulverized fuel firing in England, largely with machinery of American design. The mills, of which there are eight, are of the Raymond-Lopulco type, each having a normal capacity of $6^1/_4$ tons per hr. There are four boilers with a normal capacity of 175,000 lb per hr and a maximum of 200,000 lb, delivering steam at 375 lb per sq in. designed pressure, and final steam temperature at maximum load of 800 to 820 F. The boilers were designed by the Combustion Steam Generator Co., and a particular feature is said to be that the pressure heating surface is arranged to form the combustion chamber, being entirely constructed of four walls of plain 4-in. tubes, spaced on $4^1/_2$-in. centers, grouped vertically, and arranged in parallel, extending the whole length of the combustion chamber. The tubes are backed by a special refractory material applied in plastic form, which is in turn backed by the steel casing panels, the whole providing a dust-tight enclosure. The four corners of the combustion chamber are formed by vertical channel irons to which are attached the necessary arrangements for carrying the burners, consisting of eight plain 6-in. pipes which are introduced, two at each corner of the chamber, and projected at a predetermined angle in a position slightly above the water screen. The secondary air supply is independently controlled and may be admitted at all four corners, even if only one pair of burners is in operation. The burners are set tangentially to an imaginary circle of about 5 ft having its axis at the center of the combustion chamber. This is done to give a swirling flame which effectively scours the tubes of the vertical water walls as it passes upward through the chamber, imparting rotation to the furnace gaseous contents and insuring a long flame travel before the incandescent gases come into contact with the convection heating surface. It is said that the secret of this type of generator lies in the fact that the outer portions of the swirling flames give up a greater portion of their heat to the water-tube walls, while the inner portions are continuously being augmented with new heat. Actual figures of tests conducted on the boilers are reported in the original article. (*The Fuel Economist*, vol. 9, no. 99, December, 1933, pp. 107–113, illustrated, *d*)

Tests on a Johnson Water-Tube Boiler

THE Johnson boiler was first installed on the Canadian Pacific liner, *The Empress of Britain* (MECHANICAL ENGINEERING, Vol. 53, No. 7, July, 1931, p. 535). The present article refers to the tests carried out by the manufacturers for the British Admiralty. The boiler has no air heater and a designed evaporative capacity of just over 17 lb per sq ft of heating surface per hr. There are two longitudinal drums disposed vertically one above the other, and connected with two nests of tubes of almost semicircular contour at the sides and by a central partition of vertical tubes. It has a rear water wall only and this is shaped, in plan, as an inverted Vee. All the tubes are under the top drum below its center line and uni-directional circulation is obtained by two large downcomers situated outside the boiler casing. The uptakes are subdivided by partitions, some of the passages thus formed being fitted at their entry to the main uptake with dampers, so that the volume of gases flowing across the tubes may be divided as desired between the bottom, middle, and top portions.

TABLE 1 TEST RESULTS OF JOHNSON MARINE-TYPE WATER-TUBE BOILER

	Normal load	Overload
Evaporation per hour (actual), lb	166,318	192,122
Evaporation from and at 212 F, lb	202,492	235,531
Heating surface of boiler, sq ft	9,020	9,020
Heating surface of superheater, sq ft	1,810	1,810
Total heating surface of boiler and superheater, sq ft	10,830	10,830
Evaporation per unit of boiler heating surface, lb per sq ft	18.4	21.28
Evaporation per unit of boiler heating surface from and at 212 F, lb per sq ft	22.4	26.1
Oil burned per hour, lb	14,069	17,140
Volume of combustion chamber, cu ft	905	905
Oil burned per unit of boiler heating surface, lb per sq ft	1.55	1.9
Oil burned per unit of total heating surface, lb per sq ft	1.3	1.58
Oil burned per unit of combustion chamber volume, lb per cu ft	15.5	19
Calorific value of oil, Btu per lb	19,100	19,100
Heat release per unit of combustion-chamber volume, Btu per cu ft	296,050	362,900
Final temp of superheated steam, F	626.5	638
Temp of feedwater, F	182	182
Temp of gases entering funnel, F	797	880
CO_2 content, per cent	13.49	13.4
Efficiency of boiler and superheater, per cent	73.4	70
Air pressure in stoke-hold, in. H_2O	+3.86	+5.65
Air pressure in furnace, in. H_2O	+1.22	+2.22
Air pressure in uptake, in. H_2O	−0.7	−0.9
Working pressure of boiler, lb per sq in	300	300
Number of burners in use	10	10
Water evaporated per unit of boiler weight	1.2	1.4

One of the cardinal features of the design is the disposition of the heating surface so as to reduce the refractory lining to a minimum, the total weight of brickwork being only about 3.5 tons. The gross weight of the boiler including hot water is slightly under 57 tons with an overload evaporation of 86 tons per hr. The tests reported here consisted in the main of a 24-hr evaporative test at the designed load of 165,000 lb per hr and one of 4 hr with an overload of about 16 per cent, that is, a total evaporation of 192,000 lb per hr (see Table 1). Actually, the desired evaporation was obtained with a pressure of 3.8 in. of water gage with all burners hot, although the designed air pressure for the normal load was 4 in. The air supply was at atmospheric temperature. The furnace temperatures are not given but are stated to have been somewhat less than in boilers with a large refractory area. (*Engineering*, vol. 137, no. 3547, Jan. 5, 1934, pp. 19–20, and *The Steam Engineer*, vol. 3, no. 4, January, 1934, p. 144, 1 fig., *d*)

RAILROAD ENGINEERING (See Lubrication: Railroad-Car-Journal Oils Tested Under Severe Conditions of Temperature Change and Load)

STEAM ENGINEERING

The Parsons Hollow Turbine Blading

C. A. PARSONS & CO., Ltd., devised a method of manufacturing turbine blades hollow from end to end, in order to bring about a substantial reduction in the weight of blading and permit higher blade speeds with consequent greater output. The blades are rolled from solid billets of stainless steel, the root being integral with the blade and the hollow formation produced without recourse to any subsequent welding, brazing, or soldering process. The hole through the interior of the blade has exactly the same profile as the blade itself and tapers slightly in its length so that the walls are thinned at the top and increase gradually in thickness toward the root. By following the wall thickness in this way the theoretical requirements of uniform strength are fulfilled without adversely affecting the external form of the blade. While it is stated that the manufacturing process is patented, no details thereof are given.

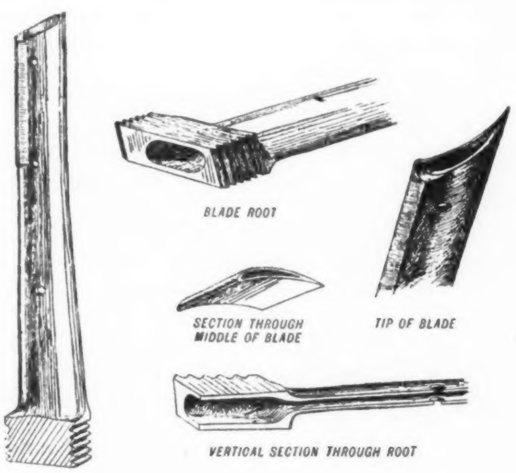


FIG. 8 PARSONS HOLLOW TURBINE BLADING

The first of these blades were fitted to the rotor of one of the 50,000-kw Parsons turbines now running in the Dunston power station and the North-Eastern Electric Supply Co., Ltd., and similar blades are being used in the 30,000-kw turbine for the Southwick Station of the Brighton Corporation. Fig. 8 shows one of the hollow blades, provided with the standard Parsons erosion-resisting shield. The blade in question is 17 in. long overall and weighs $1^1/_2$ lb. A solid blade of the same dimensions would weigh 2 lb. Furthermore, the center of gravity of the hollow blade is much nearer to the root than that of the solid blade. For equal centrifugal stresses, therefore, the hollow blade could be run at a speed 15 per cent greater than that of the solid blade. Up to the present, owing to the limitations already referred to, the maximum power that could be developed with both efficiency and safety in a 3000-rpm single-exhaust turbine working with ordinary steam conditions and high vacuum has been about 15,000-kw. With the new hollow blading this power can be raised to about 20,000 kw and 40,000 kw or more can be developed in a double-exhaust turbine running at the same speed. (*The Engineer*, vol. 157, no. 4070, Jan. 12, 1934, p. 51, illustrated, *dA*)

TESTING AND MEASUREMENT (See also Lubrication: Railroad-Car-Journal Oils Tested Under Severe Conditions of Temperature Change and Load)

Systematic Testing in a Spinning Mill

A DISCUSSION of spinning-mill testing equipment and methods, layout tests, and use of the results. The paper is of a practical character not suitable for abstracting. It is stated that in a spinning mill (this refers to the British practise) the apparatus usually consists of one or more wrap reels for yarn, a wrapping block for rovings and slivers, scales, and conversion tables, with perhaps a lea tester added. These few instruments are giving the only records of quality in many mills and the author of the paper apparently considers them generally sufficient. The first part of the paper deals with the organization of testing generally and testing for lea strength and counts. He recommends keeping one count regularly and suggests four graphs that should tell about that count.

The "range" graphs are probably the most illuminating. All through the process of spinning it is not the average value that matters; it is the weak link, the thin lengths, the coarse lengths, the incidental soft-twisted or irregular bits, and these are shown up by the "range." For comparison it is useful to express the range as a percentage of the nominal or the tested mean. The number of tests in a range group should be specified, as the range increases as the group is made larger, or the range should be converted to the standard deviation, which is independent of the size of a group.

In the other mill wrappings, lap weights, sliver, and roving counts, the interest is more in the deviation from a standard count than in the count itself. And so in the blowing room lap scales are preferred which hold the standard weights locked in a box, and show on a scale the weight by which a lap is heavy or light of the standard. This principle can be extended to the sliver wrappings by using semi-automatic scales.

As regards sampling, practically all that is found are variations. It was this that led the author to try to produce pictures of his complete results, first in two dimensions and then in three. For this part reference must be made to the original article. (A. W. Bayes, lecture to the Manchester College of Technology Textile Society, abstracted through *The Textile Manufacturer*, vol. 59, no. 708, December, 1933, pp. 477–478, *p*)

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Flexible Wages

To the Editor:

Morris P. Taylor is to be congratulated for his excellent exposition of flexible wages.[1] This is a subject which deserves more consideration from engineers than it has received. Unfortunately, most engineers seem still under the spell of the machine age which is passing together with its ideas of "wage incentives." The concept of wages in the power age will be a sort of investment in purchasing power in order to finance consumption. The most progressive writer along this line is undoubtedly Albert L. Deane, of General Motors, whose book "Investing in Wages" (Macmillan) is stimulating reading. In Mechanical Engineering for January, 1933, is outlined a plan of the present writer which has since been expanded and put in the form of a chart, "Balanced Production, Payroll, Profits, and Prices," which I would be pleased to send to any member of the A.S.M.E. An agreement was recently signed between two printing-press manufacturers of Plainfield, N. J., and the local machinists' union according to which hourly wages are to vary with the volume of orders received by the firm. This, I believe, is novel.

Wm. F. Turnbull.[2]

Tuckahoe, N. Y.

Teaching Students to Get Jobs

To the Editor:

In the report by W. A. Shoudy entitled "Lessons of Unemployment,"[3] the statement is made that "hardly one per cent of our engineers know how to hunt a job. For the past thirty years the job has hunted the man." Further on is a paragraph on the work being done by Dean J. W. Barker, of Columbia, and Dean A. A. Potter, of Purdue University. This is of particular interest to us and we feel that others will be interested in knowing what is being done in the South along these lines.

During the summer of 1933, Prof. R. S. King, head of the mechanical engineering department at the Georgia School of Technology, realized that there was a need for additional instruction which would assist students in finding a job and continuing their personal, professional, and civic development after graduation. Accordingly, Prof. R. M. Matson and I were instructed to work out a set of discussions along the foregoing lines, and the schedule of discussions has just been completed, as follows:

(1) Selling your services
(2) Self analysis to determine interest and special abilities
(3) Methods of locating prospective employers
(4) Approach of prospective employers by letter and personal interview
(5) Improvement of personality
(6) Professional development after graduation
(7) Civic duties of the engineer.

A member of the department was assigned a topic for discussion. With the exception of one, all of these men are members of the A.S.M.E.

These discussions are held in a weekly seminar period for the seniors in mechanical engineering. Alternate weeks are devoted to A.S.M.E. student-branch meetings, so that it falls to the lot of the honorary chairman of the student branch to take charge of the seminar period.

At the close of the last discussion it was voted by the students to repeat a similar set of discussions next year. We hope to be able to improve the discussions before next year and would be glad to receive suggestions.

Newton C. Ebaugh.[4]

Atlanta, Ga.

What Are Fixed Costs?

To the Editor:

The letter[5] by N. T. Pef, entitled "Super Steam Plant for the Chicago Loop," contains at least two major errors.

If labor and maintenance costs are one-third of the cost of fuel, then they amount to 7.7 cents per 1000 lb of steam for the central plant, and not 3 cents as stated, making a total of $0.457 and not $0.43.

Fixed charges are of course *not* zero for the isolated plants. What they actually are no one knows, offhand. If one assumes that, on the average, their book value is half their cost, then perhaps $0.075 would be a fair guess as to the cost per 1000 lb of steam. Then the total would be $0.445 and not $0.37.

The point is that a great number of many small plants cannot be operated as efficiently as can one large plant.

D. S. Wegg.[6]

New York, N. Y.

To the Editor:

My assumption of zero fixed charges for the isolated plant has been questioned by other engineers, but I am still of the

[1] See "Wages and Prosperity," Mechanical Engineering, January, 1934, pp. 59–61.
[2] Mem. A.S.M.E.
[3] See Mechanical Engineering, December, 1933, pp. 723–726.
[4] Georgia School of Technology. Honorary Chairman, A.S.M.E. Student Branch.
[5] See Mechanical Engineering, December, 1933, p. 778.
[6] Mem. A.S.M.E.

same opinion that in comparing the total costs of a plant that has already been built with one to be erected, the fixed charges of the first are zero, or nearly so. Fixed charges are made up of interest on the investment, rental, depreciation, taxes, and insurance. All of these, with the exception of the last, must be paid for whether the plant is in use or not.

I cannot agree with Mr. Wegg that the fixed charges should be on the basis of the book value of the plant, which he suggests be taken at one-half of the cost. If the plant is to be taken down and sold for what it is worth, then this could be taken as the fixed charges, but it will never be one-half of the original cost nor anywhere near it. Besides, dismantling the plant under the conditions of the case will not be wise, because then the isolated plant will not have any alternative should the central plant raise the price of steam. And also, a change of conditions in the future may warrant the generation of steam at the isolated plant.

N. T. PEF.[7]

Chicago, Ill.

Post-Graduation Education

TO THE EDITOR:

May I call the attention of those interested in the further education of engineers in the social sciences to an article of mine which appears in the November, 1933, issue of the *Journal of Engineering Education* and which deals with post-graduation education for engineering graduates.

In this article, it is suggested that we cannot expect to turn engineers' thoughts into social channels merely by reiterated advice; that there is little possibility of great accomplishment in the substitution in the curricula of social-science subjects for technical subjects; that, in general, the immature engineering student looks with some contempt upon any course, the subject matter of which cannot be expressed with the preciseness of a scientific subject, whence one concludes that courses on social and economic subjects seldom will be properly effective when given to undergraduate engineering students. To overcome this fundamental difficulty, it is proposed that an *incentive* be offered to young engineering graduates to study non-engineering subjects. Furthermore, heretical as it may sound, it is proposed that the incentive be a B.A. degree granted after the completion of the proper courses taken by correspondence.

Those studies in which engineering graduates are deficient would not be difficult to administer by correspondence. Various courses of study in economics, history, sociology, philosophy, and other fields could be arranged in accordance with the facilities of a given college or university. The administrators of the institution must determine the content and extent of the work, although I believe that all schools should conform to certain minimum requirements.

I am aware of the existence of many difficulties, most of which are owing to tradition. It is necessary for us to overcome our impulse to belittle education by correspondence. It will take time and effort to convince the authorities with their veto power that the results to be achieved will compensate for the sacrifice of a few of those requirements for a B.A. degree bequeathed us by our forefathers.

Upon consideration, one finds the aspects of the proposal not so radical as they first appear. We shall be dealing with men who have proved themselves, having already obtained a B.S. degree in engineering. If each institution cares for its own graduates, it will be dealing with men who have satisfied the residence requirements. Those schools which already have correspondence departments would be placed to little extra expense for administration. It may take a brave school to inaugurate the plan, but those institutions which do so will, in the course of time, possess a powerful attraction to the better type of student; and employers will not be unmindful of the advantages accruing from employing the graduates of an institution which refuses to forget that its function of educating does not cease with the awarding of a diploma. Another advantage: The university or college would keep in closer touch with a section of its alumni.

If the advantages of this plan were solely in favor of the employer and the school, I should not be so much concerned about the matter. The more important benefits will be for the individual, and hence for society. If we desire some day to have an educated society, we must teach students to continue studying through life. The road to this objective might well be paved by this plan of post-graduation education.

All points in this program indicate that the work will possess many virtues not found in resident study. The study of those intrinsically humanistic courses will come at a more mature time of life, at a time when a man is confronted with realistic social problems and, consequently, at a time when such study is likely to be appreciated. The men enrolled will be taking the work of their own free will. Hence, inspired by a desire for further education, they will exhibit an earnest attitude. Complaints come from all directions that the engineer cannot write or express himself well. In this plan of study, it can be expected that written answers in the correspondence work will improve the engineers' mode of expression.

It would be interesting if in these columns engineers would write of their own solutions to this important problem, or give suggestions that may help the cause along.

V. M. FAIRES.[8]

College Station, Texas.

Depreciation of Textile Machinery

TO THE EDITOR:

The excellent paper by Mr. Benoit[9] brings out clearly all the elements which must be considered when the rate to be charged for depreciation of machinery is determined. The subject must be considered with the reservation that at best the rate is an estimate which usually will be found to be too low or too high. However, for the preparation of financial statements and of the income-tax returns it is mandatory that provisions for depreciation be made.

It is difficult to agree with some advisors who state that the usable life of a given unit can be figured almost to a year. One must regret that such advisors are seldom around when the estimated life fixed by them expires and it is found that the unit either was scrapped several years prior or is still present and gives evidence that it may be useful for some years. The author states: "The life expectancy of any textile machine can be reasonably predicted in so far as age and wear and tear are concerned." If it is meant by this statement that a 20-year prediction may be made for a machine which it develops has a life of 18 to 22 years, then we must disagree with the statement. There are undoubtedly many textile machines which have exceeded an estimated life which had been based on "wear and tear" by some 10 to 15 years.

[7] Consulting Engineer. Jun. A.S.M.E.

[8] Professor of Mechanical Engineering, Agricultural and Mechanical College of Texas. Mem. A.S.M.E.

[9] See MECHANICAL ENGINEERING, December, 1933, pp. 732–734.

It would seem that the first consideration in making provision for depreciation would be that as the provision cannot be exact it should be excessive rather than too low. This would obviate the possibility of making too great a return to those stockholders who may not hold their interests and also prevent the overstatement of the plant assets.

The author makes certain remarks which indicate that he believes that the provision for depreciation should care not only for the original cost but for the replacement cost where it is higher than the original cost. It would seem that our problem should be limited to making provision for our original investment and that changes in costs are financial problems and should not be allowed to confuse the depreciation problem which is in itself sufficiently complex. One may easily visualize a condition whereby the provision for depreciation might be revised almost yearly so as to improve the results or to make a reduction where profits are likely to be high. During the years 1926 to 1929 we might have accumulated large reserves to replace a machine at the then costs to find that in 1933 such a machine might be purchased at less than the original costs. It is my opinion that the provision for depreciation should be made only to replace the original investment.

The author apparently suggests that the amounts provided should be segregated and held separate so that funds may be available when the replacement is made. This might prove to be an expensive method of operating if the funds so held give a very low return or are invested in securities which had to be sold at a loss when the money was needed for the replacement. The method suggested has not as yet been found to be practical, in my opinion.

PAUL E. BACAS.[10]

New York, N. Y.

TO THE EDITOR:

Aside from the question of cost accounting, the problem which must be solved in most mills is that of deciding whether there is sufficient advantage in new machinery to warrant its being bought to replace old machinery. The need for methods by which to reach a decision is apparent. Much time has been spent by accounting experts in developing formulas which can be used. Almost all the methods of the formula type are complicated and are not very convincing to the practical mill man. For these reasons, simple straightforward methods have their appeal.

That machinery depreciates is denied by nobody. Everybody, including the Government, recognizes that wear and tear are not the only elements contributing to it. The debatable question is to what extent do other elements influence the practical life of equipment.

Mr. Benoit[9] includes in the term obsolescence that characteristic which renders an old machine less economical to operate than a new one. He also includes an element which, for want of a better name, we call "inadequacy." The latter results from changes in the market, which, for instance, in the case of weaving machinery, makes it either partially or wholly useless, because of width, number of harnesses, number of boxes, or quality considerations.

Many mills in attempting to settle problems of replacement do not take into consideration the fact that their equipment differs as to age and model. For instance, if a measure of wear and tear is being established, overall figures of repair charges are used, whereas the real why in which to study the problem is to group the machinery and obtain a figure for each group. Thus a comparison of machinery now in the mill can be made with any other group of machinery in the mill or with new machinery which is offered for sale by an equipment manufacturer. The manufacturers now can give information concerning repair costs on their new equipment.

In studying measures of obsolescence, manufacturing cost is of first consequence. The cost per unit of product for each group of old machines should be found and should be compared with the cost per unit of product made by the new machine. Here again the machinery manufacturers can be of assistance because, during the past five years particularly, they have given much time to this subject.

On the score of inadequacy there is much to be said. There are mills which have looms which are not suitable for manufacturing the goods which now yield the greatest profit. Recently we had a good illustration of the effect of inadequacy. The products of a mill were taken and analyzed over a period of time to show the profit per yard and the volume of each style. The study showed that the most profitable fabrics were woven in very small quantities because the looms were not suitable. A reorganization of the equipment then was planned. A part of the old machinery was ear-marked to be thrown out and replaced by new equipment. Almost all the old looms were idle a great part of the time. This situation contributed to a higher overhead rate for the active looms because the idle machinery was not carrying its share of the load. The replacement then accomplished two things: First, it permitted the manufacture of goods upon which the profit was substantially higher; and, second, it permitted the overhead to be lower on the remaining old looms.

The point of this discussion, then, is to show that in making cost comparisons there is more to be considered than the cost of repairs, speed of machines, the number of machines per operative, the efficiency, the loss because of seconds, and other items of the same type. The item of inadequacy and its effect upon profit per unit of product, and upon overhead, frequently is of far greater importance than these other factors.

Mr. Benoit[9] points out that in the past mills have not had liquid funds available to offset the reserves for depreciation. In other words, the reserves have been nothing more than a bookkeeping fiction. The recognition of the desirability of having liquid assets for replacement purposes is spreading. We recently have seen one or two instances where mills have adopted the policy of spending each year for new machinery the amount of the depreciation which they take, and which through cost and selling price is returned to them in the form of liquid assets. A program of this nature over a period of years not only eliminates the question of having funds available, but insures that the manufacturer has the latest equipment.

To summarize these remarks, our feeling is that simple comparisons of machinery of various ages which may be in a mill with modern equipment, are far more practical than complicated replacement formulas such as have been advocated by some of our mathematically minded friends.

ALBERT PALMER.[11]

Worcester, Mass.

TO THE EDITOR:

Mr. Benoit[9] rather infers that where machinery is operated day and night, it can be considered as depreciating twice as fast as machinery operated on day run only. Our experience

[10] Acker, Bacas & McGirl, Accountants and Auditors.

[11] Research Assistant to General Manager, Crompton & Knowles Loom Works. Jun. A.S.M.E.

would lead us to believe that two-shift machinery wears out much more rapidly than twice as fast as single-shift machinery. This seems to be due to the neglect which goes along with night operation and also to the fact that the night shift is usually somewhat longer than the day shift.

J. L. TRUSLOW.[12]

Whitinsville, Mass.

TO THE EDITOR:

Mr. Benoit[9] has fully described depreciation and obsolescence, and now perhaps a few words on actual practise in the textile industry may be in order.

Fair rates for depreciation have always been more or less of a controversial question, and in 1929 the Department of Internal Revenue proposed to standardize these rates and did prepare a tentative memorandum on the subject proposing the following rates for single-shift operation with a maximum allowance of 1 per cent on textile machinery only, for 100 per cent overtime running:

Preparatory and spinning and weaving machinery	3 per cent
Power plant, heating, and electrical equipment and sprinkler systems where carried in separate accounts—not to exceed	5 per cent
Bleaching and dyeing machinery and equipment	5 per cent
Frame tenement and frame mill buildings	4 per cent
Brick tenement and brick mill buildings	2 per cent

These proposed rates seemed inadequate to the industry and in answer to this proposal, The Cotton Textile Institute in 1930, through its officers and committees, made a thorough study of the whole question and prepared a complete résumé of its findings.

Questionnaires were sent to 763 plants representing approximately 30,000,000 spindles, and 255 mills representing $14^1/_2$ million spindles replied in sufficient detail to be used for statistics. The figures hereafter quoted are from this compilation of data:

90 per cent use the straight-line method of computing depreciation
8 per cent use a composite rate for all depreciable assets
63 per cent use a composite rate for all machinery, including power plants and separate rates for buildings according to classification
18 per cent follow the last method with a separation of power plant
9 per cent use a complete classification of depreciable property with classified rates.

This last is the most accurate for cost purposes; the more simple methods are no doubt used for convenience in accounting even though the cost department has to break the figures down into more detail for cost purposes.

In general, the attitude of the Department of Internal Revenue has been to consider each case on its merits in allowing for depreciation so that there has been quite a variation in the rates allowed according to the individual situation and accounting methods of different plants and no uniform rate has ever been adopted. Out of 255 mills reporting, 64 per cent do not feel that standardized rates are feasible, and the Department has concurred with this opinion. A few mills use a flat rate per spindle year.

There are many variables that enter into the probable life of any asset, such as the character of the plant management, type of production, skill of employees, character of maintenance, and number of hours of operation.

The following figures will give an idea of the rates actually applied in the industry and the wide variation encountered:

	Average per cent
Composite rate on all property	
Single shift, 2 to 5 per cent	3.85
Double shift, 4.0 to $7^1/_2$ per cent	5.78
Composite rate on machinery and power plant	
Single shift, 2.5 to 10 per cent	4.65
Double shift, 3.0 to 20 per cent	7.11
Composite rate on manufacturing machinery	
Single shift, 2.5 to 10 per cent	4.81
Double shift 3.0 to 14 per cent	8.67
Composite rate in power plant only	
Single shift, 1 to 10 per cent	6.07
Double shift, 5 to 14 per cent	10.68
Rates on buildings of mill construction	
Single shift, 1 to 6 per cent	2.25
Double shift, $1^1/_2$ to 6 per cent	2.67
Rates on frame tenements	
Single shift, $1^1/_2$ to 10 per cent	4.06
Double shift, 2 to 10 per cent	4.40

It is interesting to note here that 75 per cent of those reporting did not feel that the rates they were using were sufficient to take care of obsolescence.

The purpose of a depreciation reserve is to provide for that element of disappearance of value in use including obsolescence which cannot be recovered by adequate maintenance and repair expenditures. This definition is in accordance with the practise of the Internal Revenue Department and with decisions of the Board of Tax Appeals and of the courts.

In accordance with this definition, depreciation applies to the original cost of the asset and of such additions as add to the value but not to repairs or replaced parts which merely serve to keep the item in operating condition.

For example, should a plain loom be changed over to be automatic, it is obviously not a repair but an addition to value. Likewise, the addition of a continuous stripper to a card or of long-draft equipment to a spinning frame is capital investment.

Ordinarily, repair parts are considered to include such items as card clothing, combs, reels, harness and shuttles, drop wires, spindles, spinning rings, rolls, belting, loom strapping, bands, tapes, cast parts, small parts, electric lamps, fuses, trucks, bobbins, spools, beams, cans, painting, and building repairs.

For convenience in allocating expense to the different departments, some of the items mentioned above are called supplies by the mills but all are classed as expense items chargeable directly to cost.

Out of 255 plants reporting, 89 per cent charged repairs and supplies direct to operating expense which indicates a preponderance of opinion in favor of this procedure.

There seems to be a general feeling that obsolescence due to improvements in machinery is much greater now than in the past. It seems to me that this condition is with us in recurring cycles.

If we go back to the early nineteen hundreds, we find the automatic loom just coming in, and I well recall plain looms still running in 1910. Through all of this period the ring frame was replacing the mule, and this replacement was still going on up to 1915 or later. In the early part of the century the old wooden top flat card was almost entirely in use and

[12] Whitin Machine Works.

the revolving top flat card just coming in. This is also true of the solid flier single-line speeder. Many of these were still unreplaced as late as 1905 by the modern fly frame.

All of these improvements were of equal or even greater importance to the industry than those of recent years.

It seems probable, since the textile industry has become united under the operation of the "codes," that, through the efforts of its control board in conjunction with the Government, uniformity in methods of accounting and cost finding will gradually work out a satisfactory solution to this problem of depreciation and obsolescence.

W. A. LANG.[13]

New York, N. Y.

A.S.M.E. Power Test Codes

Proposed Revision of Test Code for Reciprocating Steam Engines

THE A.S.M.E. Test Code for Reciprocating Steam Engines has been completely revised and rewritten. It will be the first code to conform to the new arrangement of material adopted by the A.S.M.E. Power Test Codes Committee in October, 1931. One of the principal changes is in the phrasing of the rules in the mandatory rather than advisory form. The procedures which are required in the code may, however, be replaced by alternate methods upon written agreement of the two parties to the test.

As now written, the code applies to tests of performance of the engine with or without auxiliaries. These tests may either be for the determination of (1) the thermal-economy characteristics of the engine, or (2) its capacity.

The terms used throughout the code are fully enumerated and defined in Section 2 and the units and the corresponding symbols are given.

Section 3 presents the guiding principles for the test, and deals with such matters as items on which agreement shall be reached, time of acceptance tests, preparation for test, cylinder diameter, stroke, leakage, preliminary tests, duration of tests, constancy of test conditions, instruments, and operating conditions. Many of these requirements have been changed from those in earlier codes in order to make the test procedure more exact and the results more specific.

The various instruments and methods of measurement are presented in detail in Section 4. Since indicators are one of the most important instruments used in the tests of a steam engine, they are considered at length and new limits of accuracy are introduced, not only for the indicators themselves, but also for their accompanying reducing motions and pipe connections. Rules for taking observations and time measurements are stated. Paragraphs discuss the determination of output, either as indicated horsepower, brake horsepower, or kilowatt output. Methods for the determination of electrical output are given in detail. The various methods of measuring steam quantities are considered and instructions given for the accurate determination of these quantities, including a discussion of the factors which influence the accuracy of these quantities. Acceptable methods for pressure measurements are outlined. Another change in the code is in the method of making the throttle-pressure measurement by means of an indicator. Rules are also given for the measurement of low pressures, exhaust pressures, temperature, quality of steam, and speed.

Section 5 deals with computation of results. The maximum permissible deviation of each variable of the test condition from the specified condition is stated. The various possible correction factors are defined and, in certain cases, methods are presented for the determination of these corrections. The use of the various correction factors is fully outlined. Then follow paragraphs, presenting in detail the methods and formulas for the determination of steam rate, heat rate, engine efficiency, thermal efficiency, and weighted-average steam or heat consumption. Rules are included for the determination of nominal cut-off and for nominal point of compression.

Section 6 is in the form of a table which includes a report of data and results of the tests. This form is longer and more complete than in earlier issues of this code but aims to present essential figures only for checking the economy or capacity of the engine.

This code will be presented for final approval in the near future at a meeting of the A.S.M.E. Power Test Codes Committee. Members of the A.S.M.E. who conduct or are interested in tests of reciprocating steam engines should write to the Secretary for preliminary copies of the new draft of the code. All comments or criticisms of its contents will be appreciated and should be sent to the chairman of P.T.C. Committee No. 5 on Reciprocating Steam Engines, A. G. Christie, School of Engineering, The Johns Hopkins University, Baltimore, Md. The members of the present committee are: Harte Cooke, Kenneth S. M. Davidson, Herman Diederichs, Henrik Greger, Thomas Hall, John A. Hunter, Herman G. Mueller, Bruno V. E. Nordberg, J. F. Max Patitiz, Alex V. Saharoff, A. G. Witting, and J. C. Workman.

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of this Committee in Cases Nos. 717, 763, 765, and 766 as formulated at the meeting of January 5, 1934, they having been approved by the Council. In accordance with established practise, names of inquirers have been omitted.

CASE No. 717 (Annulled)

CASE No. 763 (In the hands of the Committee)

CASE No. 765

(Interpretation of Par. A-21)

Inquiry: Par. A-21 of the Code specifies that the location of a fusible plug in a vertical fire-tube boiler shall be in an outside tube not less than one-third the length of the tube

[13] Lockwood Greene Engineers, Inc.

above the lower tube sheet. Is this distance to be measured from the top side or the bottom side of the lower tube sheet, or is it to be measured from the lower end of the tube itself either before or after beading?

Reply: It is the opinion of the Committee that the distance of the fusible plug above the lower tube sheet should be one-third the length of that part of the tube between the inner surfaces of the two tube sheets, measured from the top side of the lower tube sheet.

CASE No. 766

(Special Rule)

Inquiry: Par. 3*a* in A.S.T.M. Specifications A 149-33T for High Tensile Strength Carbon Steel Plates for Pressure Vessels (Plates 2 In. and Under in Thickness), the use of which is covered by Case No. 762, calls for uniform heat treatment of all plates over 1 in. in thickness. If it is possible to obtain the physical properties desired without heat treatment, is such heating compulsory?

Reply: The Committee has under consideration a change in this paragraph in the specifications referred to so that heat treatment will be required only when necessary to obtain the desired physical properties. Pending action on this revision, it is the opinion of the Committee that such heat treatment is optional.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PARS. P-2*a*, P-2*b*, FIRST SENTENCE OF P-103, L-2, L-3, L-5, U-12, U-13 FIRST SECTION, FIRST SENTENCE OF U-71*a*, ADD THE FOLLOWING:

OR S-26 FOR HIGH TENSILE STRENGTH CARBON STEEL PLATES FOR PRESSURE VESSELS (PLATES 2 IN. AND UNDER IN THICKNESS), OR S-27 FOR HIGH TENSILE STRENGTH CARBON STEEL PLATES FOR WELDED PRESSURE VESSELS (PLATES OVER 2 IN. UP TO AND INCLUDING 4 IN. IN THICKNESS).

PARS. P-108 AND U-76. ADD THE FOLLOWING AS SECTION (*d*) OF THE THIRD SECTION OF PAR. P-108 AND AS SECTION (*d*) OF THE FIFTH SECTION OF PAR. U-76:

(*d*) NOZZLES OR WELDED ATTACHMENTS FOR WHICH STRESS RELIEF IS REQUIRED, MAY BE LOCALLY STRESS RELIEVED BY HEATING A CIRCULAR AREA AROUND THE NOZZLE OR ATTACHMENT, PROVIDED ANY PART OF THE WELDED EDGE THEREOF IS NOT LESS THAN 12*t* (*t* = THICKNESS OF PLATE) FROM THE NEAREST ADJACENT WELDED JOINT OR OTHER ELEMENT THAT WOULD TEND TO RESTRICT THE FREE EXPANSIVE MOVEMENT OF THE HEATED AREA. THE OUTSIDE DIMENSIONS OF THIS ANNULAR RING TO BE HEATED SHALL BE AT LEAST 6*t* AWAY FROM THE OUTERMOST WELD BUT NOT LESS THAN 5 IN., AND THE ENTIRE AREA SHALL BE HEATED SIMULTANEOUSLY.

PAR. P-277. REVISE SECOND SENTENCE TO READ:

Such intervening pipe or fitting [if used] shall not be longer than the face-to-face dimension of the corresponding TEE fitting of the same diameter and pressure under the CORRESPONDING American [Tentative] Standard AS GIVEN IN TABLES A-6, A-7 AND A-8 IN THE APPENDIX AND SHALL ALSO COMPLY WITH PARS. P-12*b* AND P-286.

PAR. P-286. REVISE SECOND SENTENCE TO READ:

The dimensions of flanges subjected to boiler pressure shall conform to the American [Tentative] Standard as given in Tables A-5, A-6, A-7, or A-8 IN [of] the Appendix SUBJECT TO THE RESTRICTIONS OF PAR. P-12*b* AND except that the face of a safety valve flange and the FACE OF THE nozzle OR FITTING to which it is attached may be flat and without the raised face for pressures not exceeding 250 lb PER SQ IN. BUT SHALL HAVE THE RAISED FACE FOR HIGHER PRESSURES.

PAR. P-289. REVISE FIRST SENTENCE TO READ:

Every safety valve used on a superheater discharging superheated steam AT A TEMPERATURE OVER 450 F shall have a casing, including the base, body, bonnet and spindle of steel, steel alloy, or equivalent heat-resisting material.

PAR. P-307. INSERT THE FOLLOWING AS THE FIRST SECTION:

A BLOW-OFF AS REQUIRED HEREIN IS DEFINED AS A PIPE CONNECTION PROVIDED WITH VALVES THROUGH WHICH THE WATER IN THE BOILER MAY BE BLOWN OUT UNDER PRESSURE, EXCEPTING DRAINS SUCH AS ARE USED ON WATER COLUMNS, GAGE GLASSES, OR PIPING TO FEEDWATER REGULATORS, ETC., USED FOR THE PURPOSE OF DETERMINING THE OPERATING CONDITION OF SUCH EQUIPMENT. PIPING CONNECTIONS USED PRIMARILY FOR CONTINUOUS OPERATION SUCH AS FOR DECONCENTRATORS OR CONTINUOUS BLOW-DOWN SYSTEMS, ARE NOT CLASSED AS BLOW-OFFS.

TABLE P-6. REVISE BY INSERTING VALUES FOR FACTOR S FOR THE TEMPERATURE OF 700 F AS FOLLOWS:

	Spec. No.	700 F
Seamless medium carbon steel	S-18	12,400
Seamless low-carbon steel	S-18, S-17	9,600
Fusion welded steel	S-1	9,900
Fusion welded steel, Grade B	S-2	9,000
Fusion welded steel, Grade A	S-2	8,100
Lap-welded steel	S-18	7,600
Butt-welded steel	S-18	5,400
Lap-welded wrought iron	S-19	5,700
Butt-welded wrought iron	S-19	4,900

TABLES A-6, A-7, AND A-8. ENLARGE THESE TABLES TO INCLUDE THE FACE-TO-FACE DIMENSIONS OF A TEE AND ALSO THE MINIMUM THICKNESS OF THE CASTING OR FORGING IN EACH CLASSIFICATION FROM A.S.A. STANDARDS B16e-1932, B16a-1928 AND B16b-1928.

FIG. P-6. To be altered to show a gradual reduction in thickness of one in four rather than the abrupt change in thickness now indicated. No special distance to be prescribed within which the tapering shall be done, a long gradual taper merely to be indicated.

FIGS. P-7 AND U-5. The present definition of *W* to be replaced by the following:

W = Minimum Width of Circumferential Band, IF USED, around the Drum or Shell for Stress Relieving. FOR ANNULAR STRESS RELIEVING, SEE PAR. P-108 (U-76).

SPECIFICATIONS S-5. REVISE PAR. 5*b* TO READ:

b The yield point shall be determined by the drop of the beam OR HALT IN THE GAGE of the testing machine.

SPECIFICATIONS S-8. Par. 9*b* to be revised to make these specifications identical with A.S.T.M. A 105-33 (except adjusted service pressure ratings).

SPECIFICATIONS S-9. Par. 10*b* to be revised to make these specifications identical with A.S.T.M. A 96-33.

SPECIFICATIONS S-10. Revise Par. 10*c* to read:

b The yield point shall be determined by the drop of the beam OR HALT IN THE GAGE of the testing machine.

SPECIFICATIONS S-12. Pars. 7*b* and 9 to be revised to make these specifications identical with A.S.T.M. A 95-33.

SPECIFICATIONS S-17. Change number of corresponding A.S.T.M. Specification to read "A 83-33." Par. 6*b* to be revised.

SPECIFICATIONS S-18. Pars. 2 and 5 to be revised to make these specifications identical with A.S.T.M. Specifications A 53-33.

SPECIFICATIONS S-19. Pars. 4 and 5 to be revised to make these specifications identical with A.S.T.M. Specifications A 72-33.

SPECIFICATIONS S-20. Par. 3*b* to be revised to make these specifications identical with A.S.T.M. Specifications B 11-33.

SPECIFICATIONS S-21. Par. 3*b* to be revised to make these specifications identical with A.S.T.M. Specifications B 12-33.

SPECIFICATIONS S-22. Par. 3*b* to be revised to make these specifications identical with A.S.T.M. Specifications B 13-33.

SPECIFICATIONS S-23. Revise Pars. 3 and 12 to make these specifications identical with A.S.T.M. Specifications B 42-33.

SPECIFICATIONS S-24. Revise Pars. 4, 14, and 15 to make these specifications identical with A.S.T.M. Specifications B 43-33, for Muntz metal and high brass grades only.

PAR. U-13. ADD THE FOLLOWING AS SECTION (*c*):

c CAST STEEL MAY BE USED FOR SPECIALLY SHAPED PARTS OF VESSELS TO WHICH THE USE OF ROLLED PLATES ARE NOT ADAPTED. THE WORKING STRESS IN CAST STEEL SHALL NOT EXCEED 7000 LB PER SQ IN.

PAR. U-66. REVISE SECOND SENTENCE OF FIRST SECTION TO READ:

If the vessel is of fusion-welded construction OR IF IT HAS WELDED PRESSURE PARTS, it shall also be stamped to show the class of vessel.

PAR. U-72. REVISE SECOND SENTENCE OF SIXTH SECTION TO READ:

FILLET WELDED corner JOINTS [welds] shall NOT be USED [avoided] unless the plates forming the corner are properly supported independently of such welds.

BOOK REVIEWS AND LIBRARY NOTES

The Power Age

THE POWER AGE, Its Quest and Challenge. By Walter N. Polakov. Covici, Friede, Inc., New York, 1933. Cloth, 5 × 7¹/₄ in., 247 pp., $2.

REVIEWED BY WM. T. MAGRUDER[1]

THIS book deals with the economic history of the changes in the generation of power from the age of muscular power, the beginning of the industrial revolution and the use of water power, the development of the industrial revolution and the use of steam power, the machine age which followed, and the beginning of management, and now the so-called "power age." It contains much of the industrial history of the last 175 years. It has six charts and several tabular forms. It is overflowing with engineering facts and bristles with interesting economic statistics. It outlines the history of the management movement in the last forty years. It is not as complimentary to Frederick W. Taylor and the pioneer work that he did in starting the science of management as it is to H. L. Gantt and his charts. Its language is clear and definite and sometimes is both forceful and picturesque, as when the author says, "As if by a magic word, we set our machinery in motion by tapping new, unlimited sources of energy. The rate of production leaped, seemingly to boundless proportions. The veritable deluge of production frightened the masters of finance and industry, who learned less than half of the technique of power production and never did know a thing about distribution. . . . It seems as if we are trying to remember what we have not yet forgotten. The law of 'supply and demand' can operate when productive capacity is see-sawing with purchasing capacity, but can a bear play see-saw with a mosquito?" or, where he says that in October, 1921, "we were money-minded and power-unconscious," and, as a result, in 1930 we had an "economic headache." He quotes freely from the writings of others, but gives due credit and references. An index would improve the usefulness of the book.

The author seems to have overlooked what constitutes a machine. After describing the machine age in much detail, he sings the praises of the power age, and seems to forget that, since the beginning of the twentieth century, when the electric-power age was born, the engineer has not been getting electricity out of the clouds, but has been obtaining it by the use of a machine now called an "electric generator" and which was known in the machine age of the late 90's as an "electric dynamo," or power producer; and further, that the electric generator is driven by a machine called a prime mover using steam, water, gas, or oil. Little is said about that wonderful machine called a steam turbine, by which most electrical generators are now driven. While much that the author says about the uses of electricity in this electric-power age is exceedingly well said, it is hardly fair to charge that (p. 234) "an automobile is the child of the power age" because of its "*electric* ignition, batteries, starters, lights, and horns."

[1] Professor of Mechanical Engineering, Ohio State University, Columbus, Ohio. Mem. A.S.M.E.

Possibly, the gasoline motor might have something to say about which did the work of driving the automobile. But this is a question of perspective.

It is hardly to be expected that students of industrial history will assent to the author's statement that "the steam engine itself did not cause any revolutionary change in industry." And that "quite the contrary, it was the development of bigger and more complicated machines that revolutionized the industrial structure, that compelled the introduction of mechanical power." This may be a similar question to the one as to which came first, the hen or the egg.

The author uses italics with much effect, as when he says that "any *time-saving tool intensifies the work*," "mass production implies *interchangeable parts*" with "standardized *tolerances* of great *precision*" and with "*uniform quality of materials;*" "*the productivity per worker per year increased from 1913 to 1929 at least 50 per cent;*" and "*today management's job is essentially that of planning uninterrupted production and continuous consumption.*"

The figures given for the lowest and highest productivity per man-hour, varying up to a ratio of 1 to 224 in 306 oil refineries, is a forceful argument both for the shorter day and the scrapping of many of our economically obsolete machines and manufacturing plants.

The author points out that while the length of the working day used to be a function of the physical endurance of the worker, it now depends upon the intensity of the work, the amount of power used and the "alertness of attention," which creates mental fatigue, and that, due to the use of more technology and better management, all work is tending to become indirect.

It would seem that the practise, if not the laws, of management is due for a change because of the obsolescence of the economics of the last century and because our "industrial capital has changed its structure."

The eight techniques of planning are very suggestive at the present time in connection with proposed governmental planning of all business, banking, and industry for national economy.

Some of the author's final conclusions are that "gold, as a symbol of debt, blocks power in its natural function of relegating work to machines;" that "our present industrial ailment" is due to "our need of greater purchasing capacity, and yet we nip it in the bud; and to our need for more employment and further applications of technology, and yet we shut down plants and disemploy men and machines;" and that "what we suffer from is not technological unemployment but the unemployment of technology." In other words, now is the time to go forward and use more science and technology and develop more and newer machinery and appliances and use more electric power, rather than the reverse. Another conclusion is that "the electric-power age has created a new paradox—the profit system has become unprofitable."

The author is somewhat optimistic as to the future of a "planned economy of control which demands an engineering statesmanship which will guide itself and the affairs of state in scientific light by scientific means." The book should be read by engineers and industrial managers and studied by economists, especially those of the old school.

Porphyry Coppers

(The) PORPHYRY COPPERS. By A. B. Parsons. American Institute of Mining and Metallurgical Engineers, New York, 1933. Cloth, 6 × 10 in., 581 pp., illus., diagrams, charts, tables, maps, $5.

THIRTY-ONE per cent of the world copper production comes from twelve mines in western North and South America, known as the porphyry-copper group. Mr. Parsons here gives an able account of these mines and the men who made them, together with a description of the methods by which they are worked. The book is a valuable addition both to the history and technology of copper mining.

Mechanical engineers will be interested particularly in the chapter dealing with power-shovel mining, where it is stated that of recent years internal-combustion engines and electric motors have displaced steam as motive power in many instances, while the detailed design of the shovels has been improved immensely.

In open-cut mining the steam shovel, or rather power shovel, as against the electric shovel, is still predominant.

As regards blasting practise, Chuquimata is the only porphyry mine at which liquid oxygen explosive has been used.

Loading by power shovel is described and relative cost factors with steam shovels on railway trucks and electric shovels on caterpillar tractors are given. The factors adverse and favorable to power-shovel mining are stated.

The British National "Grid"

ELECTRICITY SUPPLY NUMBER. *The Times*, London, England, December 5, 1933, 28 pp.

REVIEWED BY GEO. A. ORROK[2]

WITH its issue of December 5, 1933, *The Times* (London) devotes 28 pages to a most interesting Electricity Supply number which covers in 32 contributions the development of the 132,000-volt interconnecting system, known as the national "Grid," and the varied uses of electricity as a source of heat, light, and power in the household, the factory, in government services, communications, agriculture, medicine, and metallurgy.

The early inception of the Grid idea was probably due to Charles Merz of the engineering firm of Merz and McLellan whose papers before the Institution of Electrical Engineers and later before the World Power Congress of 1924 warmly advocated such an interconnection. The report of the Weir Committee in 1925 led the Baldwin government to introduce and pass the Electricity Supply Act of 1926 which brought the Central Electricity Board and the Grid into existence.

Two principal functions were entrusted to the Board. One was to construct a system of main transmission lines extending over England, Scotland, and Wales, fed with current from a limited number of large generating stations, and the other was to work that system as a commercial enterprise, acting as wholesalers of electric power to the distributing companies or municipalities. The first construction contracts were placed in 1928 and 4000 miles of interconnecting high-tension lines have been built at a cost of about £27,000,000 sterling, with more than 26,000 steel towers, an average cost of about $33,000 per mile. Of the total of 4000 miles of line constructed, 3300 miles are in commission, and it is expected the complete service will be in operation from the Caledonian canal to the Channel by December 31, 1934.

Among the major problems to be solved was the standardization of frequency, a most serious problem. A standard frequency of 50 cycles was chosen and the change from the 15 to 20 different frequencies is now nearly completed. When the board was constituted the various municipalities and companies operated 500 or more separate generating stations mostly of small size and poor economy. The end of the present year should see only 135 large stations in use, all working at 50 cycles, generat-

[2] Consulting Engineer, Orrok, Myers, and Shoudy, New York, N. Y. Mem. A.S.M.E.

ing twice the energy at a materially better efficiency. It is estimated that by 1945 the saving in new generating and reserve equipment will exceed the cost of the construction of the Grid.

Meanwhile the 6,000,000,000 kwhr generated in 1927 have increased to more than 12,000,000,000 in 1932, and by 1940 the output is estimated to exceed 25,000,000,000 kwhr, or a consumption of about 500 kwhr per capita, which has been largely exceeded in this country. The 135 generating stations and 4000 miles of high-tension transmission line will be served by 273 switching and substations where the current is transferred to the individual distributing systems. Included in the 4000 miles of 132,000-volt transmission is 15 miles of oil-filled underground cable in the London district working at 132,000 volts. The cable crossings of the Thames at Dagenham and the Firth of Forth at Bonnybridge, where spans of 3050 ft are used with the wires more than 200 ft above high-tide level, are major engineering exploits.

With the completion of the Grid, the English companies enjoy advantages which in European countries were put in construction at an earlier date. Italy took advantage of the diversity between the summer melting of Alpine snows and the winter rains of the Apennines. Here the main generation is from water power with thermal power for peaks and emergencies. German companies took advantage of the enormous brown-coal areas with cheap fuel operations and interconnections. Switzerland, having no fuel, has used her hydraulic powers to the utmost and electrified her railroad system, selling the surplus to surrounding nations. France balances her fuel supplies in the north against the water powers in the Pyrenees, Alps, and Le Massif Central, while Belgium has tied in her water, gas, and steam plants in one interconnected system under unified operation. In all these cases the savings have justified the expenditure and *The Times* Electricity Supply number sets forth the great advantage of the Grid system to the British people and predicts striking savings.

Theory of Functions

THEORY OF FUNCTIONS AS APPLIED TO ENGINEERING PROBLEMS. Edited by R. Rothe, F. Ollendorff, and K. Pohlhausen. Authorized translation by Alfred Herzenberg, Dipl. Ing. Technology Press, Massachusetts Institute of Technology, Cambridge, 1933. Cloth, $6^1/_8 \times 9^1/_8$ in., 189 pp., 108 figs., \$3.50.

REVIEWED BY DR. MICHAEL A. SADOWSKY[3]

THE first part of the book, written by Dr. R. Rothe, is a review of theory of functions of a complex variable. The text leads the reader at a very fast pace as far as Cauchy-Riemann's equations, equation of potential, line-integrals, Green's theorem, Cauchy's integral formula, Poisson's integral, power series, Weierstrass' theorem of double series, analytic continuation, Taylor's and Laurent's series, the residue theorem, and conformal mapping, including Schwarz's reflection principle. The proofs are mostly omitted, sometimes sketched; the main attention has been devoted to an exact statement of the results and to illustrative explanations how to use those results for applications.

Section F of the first part is most remarkable and almost unique as far as texts on theory of functions are concerned: It contains a masterpiece of selecting and representing such formulas of the theory which are needed for the actual practical application of the theory to engineering problems. This section contains A. Korn's Hook-Integrals, the impulse function, Heaviside's and K. Wagner's formula, Heaviside's operational calculus, and applications to linear differential equations and systems of equations in connection with coupled oscillations and systems excited by harmonic oscillations. The brevity of the text combined with exceptional clarity and knowledge of what is really needed and what is not needed by engineers make section F a most valuable contribution to existing literature on the subject.

The second part of the book, written by five other authors, each one a specialist in his field, shows applications of the preceding theory to definite problems. The selected problems are not easy; on the contrary, they lead directly to the uninvestigated parts of the modern research and stimulate the reader to develop activity of his own to continue the research. In each one of the five sections of the second part the preliminary introduction enables the reader to follow immediately without any additional study of other sources. The text is readable and understandable by itself. Many references are given for details.

Concerning particulars, W. Schottky, Berlin, shows the construction of electric and magnetic fields by means of source-line potentials. K. Pohlhausen, Berlin, presents two-dimensional fields of flow. E. Weber, Brooklyn, writes on the field distribution in the neighborhood of edges. F. Ollendorff, Berlin, presents the complex treatment of electric and thermal transient phenomena, and finally, F. Noether, Breslau, investigates the spreading of electric waves along the earth.

[3] Department of Mathematics, University of Minnesota, Minneapolis, Minn.

Gyroscopic Stabilization of Land Vehicles

GYROSCOPIC STABILIZATION OF LAND VEHICLES. By J. F. S. Ross. Edward Arnold & Co., London, 1933. Cloth, $5^3/_8 \times 8^1/_2$ in., 172 pp., 42 figs., \$5.25.

REVIEWED BY H. R. LLOYD[4]

THIS book is a clearly written contribution to the theory of a subject that has usually been treated in an abstruse or a summary manner by writers on gyro stabilization.

In the preface, the author states among his objects those of determining whether monorail traction is scientifically sound and of giving the subject a more complete and orderly treatment than it has yet received. He may claim to have accomplished these aims.

The main part of the book is devoted to the primary problem of stability when the car may have oscillations about its vertical position but actually is at rest on the rail or road or traveling steadily in a straight line. The modifying effects of accelerations and curves are considered later. After writing down the equations of motion and carefully justifying the usual simplified form, the author then seeks for the most desirable type of variable external control couple to be applied to the gyro, leaving the practical question of obtaining such a couple to be considered when the type has been selected. He makes use of the ingenious step-by-step graphical method of obtaining approximate solutions direct from the differential equations for a sufficient length of time from assumed starting conditions to determine the character of the motion. The types of motion that could not be allowed are divergent oscillations of either car or gyro or permanent angular deflections of the car from the vertical position which would result in the car's eventually overturning. About a dozen different types are examined, and as no single couple would be effective, the author advocates a selected combination of three of the types to produce a satisfactory control. This combination consists

[4] Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich.

of gravitational instability of the gyro frame and couples proportional to the heeling angle of the car and to the angular velocity of the gyro frame.

The author shows how such controlling couples could be obtained in practise and criticizes constructively from this point of view the controlling devices used on monorail cars that have hitherto been designed or built.

The reader who may be looking for a practical guide to be immediately applied to the design of monorail cars may be disappointed. He may consider the book suffers from some of the defects of a thesis prepared for degree purposes. There is no doubt, however, that he will find it of great help in comprehending the fundamental principles and the particular problem that must be considered in design.

The question of stabilizing an inherently unstable system brings in many problems that do not arise in the stabilizing of a naturally stable system such as a ship. There is much more experimental work to be done before the problem can be completely solved. This book will help to focus such experiments in the promising directions.

The book contains a valuable summary of conclusions for those who have not the time or the training to absorb all the mathematics. A detailed account of the more important literature of the subject and a good bibliography are also included.

Books Received in the Library

A.T.M., Archiv für technisches Messen. Nos. 27–30, September–December, 1933. R. Oldenbourg, Munich and Berlin. Paper, 8 × 12 in., pp. 125–170, illus., diagrams, charts, tables, 1.50 rm. for each number. This work, which appears serially, is intended to form an encyclopedia of measuring instruments and methods used in engineering. Brief articles by specialists cover a wide variety of topics. New instruments are described by the manufacturers. The material is classified and so arranged that it may be sorted and placed in loose-leaf binders for convenient reference.

BILDWORT ENGLISCH Technische Sprachhefte 9. MACHINE PARTS. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 8 in., 33 pp., diagrams, tables, 1.50 rm. This pamphlet is intended to facilitate the learning of engineering English by Germans. An essay introduces all the usual terminology of machine parts and these words are defined by machine drawings, properly labeled. There is also a brief English-German glossary. The pamphlet is one of a series prepared by the Verein deutscher Ingenieure.

COLOUR SCIENCE. Part 2, Applied Colour Science. By W. Ostwald, translated by J. S. Taylor. Winsor & Newton, London and New York, 1933. Cloth, 6 × 9 in., 173 pp., diagrams, charts, $3.75. Ostwald's "Farblehre," now made completely accessible to English readers, incorporates the results of his researches upon the measurement and standardization of color. The concluding volume of the translation discusses especially the applications of Ostwald's theory of color to color measurement, color mixtures and pigments, and to the discussion of color harmony. There is much to interest printers, painters, textile manufacturers, and other users of colors.

CONSTRUCTION MÉCANIQUE (Agenda Dunod). By J. Izart. Dunod, Paris, 1934. Leather, 4 × 6 in., 340 pp., diagrams, charts, tables, 20 fr. This member of the inexpensive series of handbooks issued by Dunod contains textual and numerical information frequently wanted by mechanical engineers and machinists. Machine elements, piping, shafting, hoists, etc. are treated, and there is a careful summary of French labor laws.

CRYSTALLINE STRUCTURE IN RELATION TO FAILURE OF METALS, especially by Fatigue. (Edgar Marburg Lecture, 1933.) By H. J. Gough. American Society for Testing Materials, Philadelphia, 1933. Paper, 6 × 9 in., 111 pp., illus., diagrams, charts, $1. This is the 1933 Edgar Marburg lecture, delivered before the American Society for Testing Materials and the Engineering Section of the American Association for the Advancement of Science. Dr. Gough here discusses the knowledge of deformation and fracture under mechanical forces which has resulted from his extensive studies of single metallic crystals. The lecture summarizes what is known of the nature of solid bodies in an effective way. It should interest chemists and physicists, as well as engineers and metallurgists. There is a bibliography.

DIE BRENNKRAFTMASCHINEN, VOL. 1. GRUNDLAGEN. Thermodynamik, Wärmeübergang, Brennstoffe, Verbrennung, Arbeitsverfahren. (Sammlung Göschen 1076.) By P. Meyer. Walter de Gruyter & Co., Berlin and Leipzig, 1934. Cloth, 4 × 6 in., 88 pp., charts, diagrams, tables, 1.62 rm. The first volume of a concise textbook on internal-combustion engines, in which difficult mathematics is avoided and a simple, readable text is attempted. The fundamental thermodynamic principles, heat transfer, fuels, combustion, and other generalities are discussed in this volume, which is to be followed by descriptions of the various types of engines.

DARDELET THREAD HANDBOOK FOR ENGINEERS, Designers and Mechanics, containing comprehensive information relative to the Dardelet Self-Locking Screw Thread. Dardelet Threadlock Corporation, New York, 1933. Leather, 5 × 7 in., 220 pp., illus., diagrams, charts, tables, $2. The Dardelet thread is a novel self-locking thread which makes possible a screw coupling that can readily be assembled and dissembled with a wrench or other tool, but will not become unscrewed accidentally. This booklet, issued by the manufacturer, describes the theory and design of the thread, gives the results of tests, and contains practical information upon thread forming, heat treatment, uses, etc.

DEUTSCH-ENGLISCHES FACHWÖRTERBUCH DER METALLURGIE (Eisen- und Metallhüttenkunde). Part 1. Deutsch-Englisch. Edited by H. Freeman. Otto Spamer, Verlag, Leipzig, 1933. Leather, 5 × 7 in., 327 pp., 25 rm. This seems a very satisfactory dictionary for the reader of German metallurgical writings. Over 33,000 terms are included, with accurate English equivalents. The vocabulary includes, in addition to metallurgical expressions, those of mechanical and electrical engineering, chemistry and physics, as well as general words which are likely to occur in writings on metallurgy. There are also a number of convenient conversion tables and 750 conversion factors. The book is small enough for the pocket, and the print is legible, though small.

DIFFERENTIAL EQUATIONS. By L. R. Ford. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 263 pp., diagrams, charts, $2.50. A course in the subject which can be covered in a year by a class of ordinary ability. In the introductory part of the presentation the geometrical and intuitive aspects of the subject are emphasized. Succeeding this the rigorous method of approach is presented. An unusual feature is a chapter on interpolation and numerical integration.

ELEMENTS OF HYDRAULIC POWER GENERATION. By A. M. Greene, Jr. John Wiley & Sons, New York, 1934. Paper, 6 × 9 in., 58 pp., illus., diagrams, $1. A brief exposition, covering some fifty pages, of the apparatus used to develop hydraulic power. The uses, limitations, and names of the modern forms of hydraulic machinery are presented in a clear, readable way, with the reasons for these forms. The book can be used as a background for the study of theoretical hydraulics, and supplements, in the hydraulic field, the author's "Elements of Power Generation."

FORSCHUNGSHEFT 363. (1) Die Diesellokomotive mit unmittelbarem Antrieb, by A. Langen. (2) Untersuchungen über an Spülvorgang an Zweitaktmaschinen, by W. Lindner. V.D.I. Verlag, Berlin, 1933. Paper, 8 × 12 in., 22 pp., illus., diagrams, charts, tables, 5 rm. The first of the two reports in this publication describes tests of an experimental direct-connected Diesel locomotive. This engine, of 1000 hp, has been thoroughly tested in the shop and is now to be tried in service. The second paper gives the result of an investigation of the scavenging process in two-cycle engines, undertaken to find ways to improve it.

FUNKTIONENTAFELN mit Formen und Kurven. By E. Jahnke and F. Emde. Second edition. B. G. Teubner, Leipzig and Berlin, 1933. Cloth, 6 × 10 in., 330 pp., diagrams, charts, tables, 16 rm. This work supplements ordinary tables of mathematical functions. It provides a large collection of tables of higher functions used by calculators, accompanied in each case by a bibliography of the most important books. A unique feature is the graphical representation of the general character of the complex functions by perspective diagrams. The tables are clearly printed and sufficiently correct for most purposes. References to more accurate tables are given throughout. The new edition, which is almost twice as large as its predecessor, and has the explanatory text in English as well as in German, will be welcomed by all calculators.

GAS CALORIMETRY. By C. G. Hyde and F. E. Mills, with introduction by C. V. Boys. Ernest Benn, Ltd., London, 1932. Cloth, 7 ×

10 in., 376 pp., illus., diagrams, charts, tables, 42s. With the increasing substitution of calorific power for illuminating power as the measure of the monetary value of gas to a consumer, the calorimetry of gas supplies is becoming important. In the present work two experts have made available the results of wide practical experience as gas chemists and referees. The treatise covers the subject comprehensively, giving detailed advice upon laboratory planning and equipment, methods of measurement, and the calculation of results. All varieties of calorimeters are described, with explanations of many commercial types. A chapter is devoted to the control of calorific value.

DIE GETRIEBE FÜR NORMDREHZAHLEN. Neue Rechnungswege und Hilfstafeln für den Konstrukteur. By R. Germar. J. Springer, Berlin, 1932. Paper, 7 × 10 in., 62 pp., diagrams, charts, tables, 9.60 rm. The purpose of this book is to facilitate the practical application of the system of standardized idling speeds for machine tools developed by Professor Schlesinger. The effects of this plan of standardization upon the design of gearing and speed changers are explained, and its advantages set forth. The authors then carry through the calculations for the gears that come in question practically and present the results in tables from which the proper gears for any desired purpose can be selected at once, and their diameters and ratios obtained without calculation.

GREAT BRITAIN. Department of Scientific and Industrial Research. FOOD INVESTIGATION Special Report No. 8. MEASUREMENT OF HUMIDITY IN CLOSED SPACES. His Majesty's Stationery Office, London, 1933. Paper, 6 × 10 in., 70 pp., illus., diagrams, charts, tables, 1s 6d. (Can be obtained from British Library of Information, New York, $0.50.) The greater part of this report is devoted to experiments with hygrometers, undertaken primarily to ascertain their reliability as measurers of humidity. The existing types are discussed in detail, and a number of novel instruments designed to meet special requirements are described. A brief discussion of methods of air-conditioning is included. The report is based upon work by Dr. Ezer Griffiths and Mr. J. H. Awbery, and is an amplification of one published in 1925.

GREAT BRITAIN. Department of Scientific and Industrial Research. REPORT OF THE FUEL RESEARCH BOARD for the Year ended March 31, 1933; with Report of the Director of Fuel Research. His Majesty's Stationery Office, London, 1933. Paper, 6 × 10 in., 140 pp., illus., diagrams, charts, tables, 2s 6d. (Obtainable from British Library of Information, New York, $0.77.) Among the lines along which progress is reported are the cleaning of fine coal, carbonization and gasification processes, gasoline, the hydrogenation of tar and coal, firing of pulverized fuel, as well as various minor problems of fuel utilization.

HANDBUCH DER LANDMASCHINENTECHNIK, Vol. 2, No. 2. By G. Kühne. Julius Springer, Berlin, 1934. Paper, 8 × 11 in., 386 pp., diagrams, charts, 28.50 rm. This volume, which completes this useful treatise on agricultural machinery, contains material on the preparation of fodder and on the transportation of agricultural bulk products. Hay and vegetable cutters, mills for grinding grain and oil-cake, washing machines, hay balers, farm wagons, hoisting machinery, etc., are discussed. Much information is given upon design and construction, illustrated by examples.

HERMANN RECKNAGELS HILFSTAFELN ZUR BERECHNUNG VON WARMWASSERHEIZUNGEN. By O. Ginsberg. Sixth edition. R. Oldenbourg, München and Berlin, 1933. Paper, 8 × 12 in., 35 pp., tables, 4 rm. This pamphlet contains forty-six numerical tables intended to simplify the calculation of hot-water heating plants, which have been very popular in Germany. The present edition has been entirely revised in the light of new investigations and changes in practise.

INDUSTRIAL CHEMISTRY. By E. R. Riegel. Chemical Catalog Co., New York, 1933. Cloth, 6 × 9 in., 784 pp., illus., diagrams, charts, tables, $6. The book aims to present in a single volume a picture of the commercial activities that make up industrial chemistry. The entire field, both organic and inorganic, is covered, and in addition there are chapters upon the machinery, materials, and control instruments of chemical engineering. The accounts of processes are necessarily brief, because of the vast field covered, but they are representative of current practise. The volume is convenient as a reference work, as well as for class-room use. Brief bibliographies are provided for each chapter.

INTERNATIONAL ACETYLENE ASSOCIATION PROCEEDINGS, 33rd Annual Convention, 1932. The Association, New York, N. Y., 1933. Cloth, 6 × 9 in., 201 pp., not for sale. The papers presented in this volume deal with the uses of oxy-acetylene cutting and welding processes in various industries and manufacturing processes. The use of welded piping in power plants and residences, welding in the aircraft industry and in railroad and truck maintenance, weld testing, etc. are discussed. The reports of the Association and a list of its members are also included.

INVENTIONS, PATENTS, AND TRADEMARKS, Their Protection and Promotion. By M. Wright. Second edition. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 8 in., 310 pp., $2.50. An experienced attorney here discusses in a practical way many questions frequently asked by inventors. He tells how to choose a patent attorney, what patent-office procedure is, and how to estimate the value of a patent. Methods of disposing of patents are described, the relations of inventor and employer are discussed, and various traps set for patentees are noted.

MACRAE'S BLUE BOOK CONSOLIDATED WITH HENDRICK'S COMMERCIAL REGISTER. Forty-First Annual Edition, 1933–1934. MacRae's Blue Book Co., Chicago and New York, 1933. Cloth, 8 × 11 in., 3332 pp., illus., $15. This directory of manufacturers and dealers is an extremely useful guide to sources of supply for every ordinary article of commerce. In addition to an address list of manufacturers and dealers, and a thoroughly indexed list of materials and their makers, the book has a long list of trade names and a section describing the trade facilities of all towns of one thousand or more population.

MARKENBEZEICHNUNGEN IM FEUERFEST-FACH UND IM OFENBAU. Edited by L. Litinsky. L. Litinsky, Verlag, Leipzig, 1934. Paper, 6 × 9 in., 112 pp., 6 rm. A pamphlet containing an alphabetical list of brand and trade mark names used by manufacturers of refractories and industrial furnaces. Approximately fifteen hundred names are given, with the addresses of firms or dealers. The list is international in scope.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, Vol. 2, Part 9, November, 1933. (1) Die Seile für die Gipfelstrecke der bayerischen Zugspitzbahn, by R. Meebold. (2) Untersuchungen über den Reitstockspitzendruck beim Drehen schwerer Werkstücke, by K. F. Brill. (3) Der Widerstand einer Schweissverbindung gegen Beanspruchung durch Schrumpfen, by R. Hochheim. V.D.I. Verlag, Berlin. Paper, 8 × 12 in., pp. 235–262, illus., diagrams, charts, tables, 3.15 rm. The three papers here presented emanate from the research laboratories of various German factories and discuss the construction and testing of the cable for a large passenger cableway, the pressures on lathe centers supporting heavy pieces, and the resistance to contraction of welds.

MITTEILUNGEN DES HYDRAULISCHEN INSTITUTS DER TECHNISCHEN HOCHSCHULE MÜNCHEN, No. 7, 1933. By D. Thoma. R. Oldenbourg, Munich and Berlin. Paper, 8 × 11 in., 86 pp., illus., diagrams, charts, tables, 5.80 rm. Four papers describing recent work at the Institute are contained in this work. The first describes investigations of the lubricating capacity of oils and fats, in which the relation of this property to the nature of the metals in contact, the effect of small additions of fatty acids to mineral oils, and the properties of fats were studied. The second treats of flow over weirs, describing the influence of various factors, such as rounded weir crests, upon the discharge. The effects of sudden stoppage upon turbine pumping plants are discussed in the third paper, based upon experiments with large and small pumps. The final paper describes a new hot-wire instrument for determining the direction and magnitude of the velocity of turbulent water.

PLANNING AND NATIONAL RECOVERY, Planning Problems Presented at the Twenty-Fifth National Conference on City Planning, held jointly with the American Civic Association, at Baltimore, Maryland, October 9–11, 1933. Published for the Conference by Wm. F. Fell Co., Philadelphia, Pa. Cloth, 6 × 9 in., 158 pp., tables, $3. The papers presented at this conference fall into three groups: planning and national recovery; large-scale regional and rural-land planning; slum clearance and city planning. Various aspects of each of these problems were presented by experts and discussed by others.

PLASTIC MOLDING. An Introduction to the Materials, Equipment and Methods Used in the Fabrication of Plastic Products. By L. F. Rahm. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 246 pp., illus., diagrams, tables, $3. A general view of the methods and equipment used in the molding of plastics is presented. The physical characteristics of the important plastics are set forth. The design of molds is discussed in detail and attention is paid to molding presses and other equipment, and the erection of molding plants. An appendix lists the trade names and manufacturers of some eight hundred plastic products.

POWER SUPPLY ECONOMICS. By J. D. Justin and W. G. Mervine. John Wiley & Sons, New York, 1934. Cloth, 6 × 9 in., 276 pp., illus., charts, maps, tables, $3.50. The executives and engineers of power companies and industrial concerns are constantly confronted by such problems as the prediction of future power demands, the comparative merits of various methods of obtaining additional power, and the determination of the size of plant to be built. The present book is intended to assist in the solution of these questions. It discusses load predictions, the internal economics of steam-electric and hydroelectric plants and the cost of power from each, peak-load plants, oil-engine plants, purchased power, and similar topics; setting forth the general economic principles which govern the selection of the best solution.

LES PRIMES SUR SALAIRES DANS LES ENTREPRISES INDUSTRIELLES. (Bibliothèque Professionnelle et Sociale.) By A. Perren, preface by P. E. Bonjour. Delachaux & Niestlé S.A., Neuchatel (Switzerland) and Paris, 1933. Paper, 6 × 9 in., 144 pp., illus., diagrams, charts, tables, 6 Swiss fr. This work provides a compact discussion of bonus systems of wage payment. The author first lays down the fundamental principle that underlies all such systems, examines the factors which may influence the choice for a given establishment, and states the conditions preliminary to the practical adoption of one. He then reviews the various systems that are in use, pointing out their advantages and disadvantages. The book is an excellent review of the subject.

RICHTLINIEN FÜR EINKAUF UND PRUFUNG VON SCHMIERMITTELN. Edited by Verein deutscher Eisenhüttenleute and Deutscher Normenausschuss. Sixth edition. Beuth Verlag, Berlin; Verlag Stahleisen, Düsseldorf, 1933. Leather, 6 × 8 in., 126 pp., diagrams, charts, tables, 6.75 rm. Standard specifications for all commercial varieties of lubricants and for testing are presented in this manual, together with information on general characteristics and upon the practical importance of the various properties of oils and fats. The standards and directions included are those of the German Bureau of Standards, the German Society for Testing Materials, and other national organizations, so that the work has official standing.

RIEMEN- UND SEILTRIEBE. (Sammlung Göschen 1075.) By E. vom Ende. Walter de Gruyter & Co., Berlin and Leipzig, 1933. Cloth, 4 × 6 in., 110 pp., illus., diagrams, charts, tables, 1.62 rm. A concise description of modern belt and rope drives, with data on their design and installation.

DIE ROHRNETZE DER WARMWASSER-HEIZUNGSANLAGEN. (Beihefte zum Gesundheits-Ingenieur, Series 1, Vol. 32.) By J. Gronningsaeter. R. Oldenbourg, München and Berlin, 1933. Paper, 9 × 12 in., 46 pp., diagrams, charts, tables, 10 rm. This pamphlet is intended to enable the designer of hot-water heating systems to plan the most economical pipe system. The author discusses the most economical thickness of insulation, distribution of the pressure drop in the circuit, height of pressure, and temperature loss. Tables and graphs are included which enable these calculations to be made rapidly, and the use of the methods is explained.

ROHRHYDRAULIK, Allgemeine Grundlagen, Forschung, Praktische Berechnung und Ausführung von Rohrleitungen. By H. Richter. Julius Springer, Berlin, 1934. Cloth, 6 × 10 in., 256 pp., diagrams, charts, tables, 22.50 rm. This monograph aims to present a practical summary of all the available information upon the flow of fluids in pipes which is of practical usefulness. The first section is devoted to the physical principles of flow and includes an extensive collection of numerical data upon the viscosities of industrial fluids and mixtures. Section two discusses theoretical considerations and the data upon the flow of liquids and gases in pipes obtained through the research work of recent years. The third section treats of the practical design and construction of pipe lines for liquids and gases. It contains a collection of useful formulas for various conditions of flow, with examples of their use.

SCIENCE MUSEUM, South Kensington. HANDBOOK OF THE COLLECTIONS ILLUSTRATING PUMPING MACHINERY, Part 2. Descriptive Catalog. By G. F. Westcott. His Majesty's Stationery Office, London, 1933. Paper, 6 × 10 in., 195 pp., illus., 3s 6d. The collection at the Science Museum contains over five hundred exhibits, selected to illustrate past and present practise relating to pumps of all kinds. The exhibits are described in detail in this catalog, which contains excellent cuts of a number of the more important ones. The first section of the "Handbook" consisted of historical notes on pumping machinery; the two sections form a valuable work on the history of the subject, which all students of the history of machinery will wish.

STEEL-MAKERS. By H. Brearley. Longmans, Green & Co., London, New York, Toronto, 1933. Cloth, 6 × 8 in., 156 pp., diagrams, 5s. A discursive, readable description of the art of making crucible steel, by one long prominent in the industry. Mr. Brearley writes of the process and of the men who made Sheffield tool-steel famous before "scientific-control" was known.

STORY OF AIRCRAFT. By C. Fraser. Thomas Y. Crowell Co., New York, 1933. Cloth, 6 × 8 in., 510 pp., illus., $2.50. A lively, popular history of aviation, from Daedulus to Balbo. The development of balloons, airships, airplanes, and gliders is explained, and the outstanding military and civil achievements of the century are described.

SYMPOSIUM ON CAST IRON, held at Joint Meeting of the American Foundrymen's Association and the American Society for Testing Materials. American Society for Testing Materials, Philadelphia, 1933. Paper, 6 × 9 in., 164 pp., illus., diagrams, charts, tables, $1; cloth, $1.25. The purpose of this symposium is to provide concise, authoritative information upon the composition, metallurgy, properties and uses of the many grades of cast iron now available. Sections are devoted to the metallurgy, properties, classification and specifications, heat treatment and welding of cast iron, as well as one to factors in casting design which are important. The collection and presentation of the information has been directed by a committee of experts, appointed by the American Foundrymen's Association and the American Society for Testing Materials.

TABLES OF INTEGRALS AND OTHER MATHEMATICAL DATA. By H. B. Dwight. Macmillan Co., New York, 1934. Cloth, 6 × 9 in., 222 pp., charts, tables, $1.50. A useful collection of derivatives and integrals of the more important functions, accompanied by a selection of tables of numerical values and provided with an adequate index. The book is clearly printed and of convenient size, and adapted to the needs of college students.

TECHNIK DES KUNSTHANDWERKS IM ZEHNTEN JAHRHUNDERT DES THEOPHILUS PRESBYTER DIVERSARUM ARTIUM SCHEDULA. Translated and edited by W. Theobald. V.D.I. Verlag, Berlin, 1933. Half calf, 8 × 12 in., 553 pp., illus., diagrams, 60 rm. For many years Dr. Theobald has been occupied with a translation of the "Schedula diversarum artium" of Theophilus the Priest, written according to the latest conclusions, in the tenth century. This work, which describes the methods of glass and metal working more thoroughly than any other of the time, has hitherto never been studied by a translator capable of discussing it from a technical point of view and so has been little used by students of the history of technology.

With the present publication, the difficulties disappear. Dr. Theobald provides a careful edition of the text, with an intelligent translation, and over three hundred pages of notes which afford a wealth of information upon the technology of the Middle Ages. Theophilus describes the equipment of the workshop, the manufacture of tools, metal smelting and refining, bell founding, goldsmithing, and other crafts. The book is a handsome production, which many engineers and metallurgists will find of interest.

DIE TECHNOLOGIE DES EDELSTAHLES, Aufbau, Verwendung, Herstellung, Behandlung, Prüfung und Fehler des Edelstahles. By A. Kropf. Wilhelm Knapp, Halle (Saale), 1934. Paper, 6 × 9 in., 264 pp., illus., diagrams, charts, tables, 12.80 rm. A concise, yet comprehensive, review of present knowledge concerning alloy steels, in which special attention is given to practical questions, rather than to theoretical considerations. The characteristics of the various alloy steels are described and methods of manufacturing, working, and heat treating are discussed. Methods of testing are given, with the standard specifications of England, Germany, Switzerland, and the United States. One chapter is devoted to flaws and their origins.

THEORY OF FUNCTIONS AS APPLIED TO ENGINEERING PROBLEMS. Edited by R. Rothe, F. Ollendorff, and K. Pohlhausen, authorized translation by Alfred Herzenberg. Technology Press, Massachusetts Institute of Technology, Cambridge, 1933. Cloth, 6 × 10 in., 189 pp., diagrams, charts, $3.50. In 1929 and 1930 the Berlin Institute of Technology and the Berlin Electrical Engineering Society arranged a series of lectures upon the theory of functions and its practical applications to engineering problems. These lectures are here presented in translation, forming, it is said, the first book in English upon the subject.

The first half of the volume, edited by R. Rothe, deals with the theory from the point of view of pure mathematics and gives a general knowledge of the methods of function theory. The second part consists of five lectures upon specific applications, chiefly to problems of electrical engineering; the construction of electric and magnetic fields by means of source-line potentials; two-dimensional fields of flow; the field distribution in the neighborhood of edges; the complex treatment of electric and thermal transient phenomena; and the spreading electric waves along the earth.

THEORETICAL PHYSICS. Vol. 2, Electromagnetism and Optics. Maxwell-Lorentz. By W. Wilson. Methuen & Co., London; E. P. Dutton & Co., New York, 1933. Cloth, 6 × 9 in., 315 pp., diagrams, tables, $5.75. The second volume of this text is devoted to electricity and optics. In it, as in the preceding volume, the subject matter has been selected to present physical theory as a coherent logical unity. Electrostatics, magnetostatics, the fundamentals of electrodynamics, thermoelectricity, Maxwell's theory, electron theory, dispersion, scattering of radiation, etc. are discussed. Special features are the way in which the complexities of electrical units are handled, the discussion of the dimensions of physical quantities, and the treatment of electromagnetic momentum and mass.

THÉORIE GÉNÉRALE DU COUP DE BÉLIER. By C. Jaeger. Dunod, Paris, 1933. Paper, 7 × 10 in., 268 pp., diagrams, charts, tables, 86 fr. Allievi's theory of water hammer, which is usually applied to the solution of water-hammer problems, is rigorously applicable only to conduits of uniform diameter and elasticity. The present work extends Allievi's theory to a general form by which the pressure can be calculated at any point of a conduit in which the sections and elasticity vary and which empties into a surge tank of any type, under any conditions of gate closure.

WÄRMETECHNISCHE ARBEITSMAPPE. Gesammelte Arbeitblätter aus den letzten Jahrgängen von "Archiv für Wärmewirtschaft und Dampfkesselwesen." V.D.I. Verlag, Berlin, 1934. Paper, 9 × 12 in., 46 Arbeitblätter, charts, maps, 4.80 rm. Since 1932 the "Archiv fuer Waermewirtschaft und Dampfkesselwesen" has been publishing diagrams designed to provide the engineer with some results of recent research work in heat engineering, arranged in a form which permits ready use in practise. Forty-six charts are now published in loose-leaf form. They provide data upon steam-boiler firing, steam engines, steam distribution, heating, etc., in very readable graphic charts, each accompanied by an example of its use.

DER WÄRME- UND STOFFAUSTAUSCH DARGESTELLT IM MOLLIERSCHEN ZUSTANDSDIAGRAMM FÜR ZWEISTOFFGEMISCHE. By A. Busemann. Julius Springer, Berlin, 1933. Paper, 6 × 10 in., 75 pp., diagrams, charts tables, 6 rm. By introducing a new concept, "exchange flow," which includes radiation, diffusion, and convection, the author shows how the problems of heat exchange may be solved more easily and exactly than heretofore. The new factor may be introduced into the Mollier phase diagram for mixtures of two components, and is accurate for both laminar and turbulent flow.

DIE WECHSELFESTIGKEIT METALLISCHER WERKSTOFFE, ihre Bestimmung und Anwendung. By W. Herold. Julius Springer, Vienna, 1934. Cloth, 6 × 9 in., 276 pp., illus., diagrams, charts, tables, 24 rm. This work, by the director of research for the Austrian Automobile Works, is intended to bring together the scattered information available upon the fatigue resistance of metals and methods of testing it, with some indications of the practical uses of such tests. The theoretical principles are discussed, as well as the various causes of fatigue, and the results of practical tests of the commercial metals and alloys are summarized. There is a lengthy bibliography.

YANTRIKA CHITRAKARI. Vol. 1 (Mechanical Drawing). (In Hindi, vernacular of India.) By O. N. Sharma. Gulab-Bari, Ajmer, India (Publisher), Udyoga Mandir, Ajmer. Paper, 5 × 7 in., illus., diagrams, tables, Rupees 2/8/–. This book is an introduction to mechanical drawing, written in Hindi. The treatment is elementary and is apparently directed to the instruction of machinists and shopmen in the rudiments of the art. An appendix contains a large collection of tables frequently wanted by the draftsman, and there is a brief Hindi-English glossary.

WHAT'S GOING ON

Index to "Mechanical Engineering"

MEMBERS of The American Society of Mechanical Engineers, to whom the *Record and Index* for 1933 has been distributed, will find in it an index to MECHANICAL ENGINEERING. Any one desiring a copy of this index for use in binding with the 1933 volume of MECHANICAL ENGINEERING can secure one by addressing The Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Harrisburg, Pa., Hospitable to Engineers

THE Engineers Society of Pennsylvania, 441 Market St., Harrisburg, Pa., through its secretary, Mr. G. A. Rahn, has extended an invitation to all members of the A.S.M.E. to make use of the facilities of its headquarters in the Pennsylvania Station Annex. Members of the A.S.M.E. are invited to use the society's reading room and at end meetings and its daily luncheons whenever they are in Harrisburg.

A.S.M.E. Appointments

THE following appointments were reported at the December 3, 1933, meeting of the Executive Committee of the A.S.M.E. Council: Standing Committee on Education and Training, C. J. Freund (to fill unexpired term of S. S. Edmands, December, 1936); Gantt Medal Board, David B. Porter (3-year term); Power Test Codes Individual Committee No. 9 on Displacement Compressors and Blowers, Rawleigh M. Johnson; and National Fire Waste Council, H. O. Lacount and John A. Neale (representatives at meetings of Council).

A.S.M.E. Transactions for February, 1934

THE February issue of the Transactions of the A.S.M.E., which, under the new plan approved by Council at its December, 1933, meeting, will combine all of the sections previously issued independently and which is being sent to every member in good standing now registered in any of the professional divisions of the Society, contains the following papers:

Noise Reduction in Cabin Airplanes (AER-56-2), by Preston R. Bassett and Stephen J. Zand

Some Studies on the Flutter of Airfoils and Propellers (AER-56-3), W. Harold Taylor

Characteristics of Large Hell Gate Direct-Fired Boiler Units (FSP-56-2), W. E. Caldwell

Utility of Variable-Displacement Oil-Pressure Pumps for Hot-Pressing in Plywood Operations (WDI-56-2), Elek K. Benedek.

A.P.I. to Meet at State College

THE Production Division, Eastern District, of the American Petroleum Institute will meet at State College, Pa., April 6 and 7. It has been the policy of the Pennsylvania State College Mineral Industries Division to hold an annual Petroleum and Natural Gas Conference at State College each spring. This year's Petroleum and Natural Gas Conference is being dispensed with to allow the Division of Production of the American Petroleum Institute to hold its annual meeting there. State College officials are cooperating in the arrangements and program that are being formed for the Institute's meeting.

Coming A.S.M.E. Meetings

TULSA, OKLA., MAY 14 TO 16

THE Petroleum Division of The American Society of Mechanical Engineers will hold a national technical meeting in Tulsa, Okla., May 14 to 16, during the International Petroleum Exposition. The technical program of the meeting will consist of more than 20 papers covering production, transportation,

and refining of petroleum. T. D. Tifft, is arranging the refining program while the transportation and production program is in the charge of the chairmen of these committees at Tulsa.

BERKELEY, CALIF., MAY 19 TO 21

The Aeronautic and Hydraulic Divisions of the A.S.M.E. will hold a joint national meeting at the University of California, May 19 to 21, during the summer meeting of the American Association for the Advancement of Science. Several other societies are also cooperating. Prof. B. M. Woods, of the University of California, is in charge of the meeting arrangements.

DENVER, JUNE 25 TO 28

The 1934 Semi-Annual Meeting of the A.S.M.E. will be held in Denver, Colo., June 25 to 28 with headquarters at the Cosmopolitan Hotel. A tentative program, prepared by the Colorado Section of the Society, includes papers which deal with recent mechanical-engineering developments in mining, fuel utilization, sugar refining, humidity, and management problems. Inspection trips to plants and mines are being arranged. Automobile and railroad tours in conjunction with the meeting are under consideration. Members interested in such tours are requested to notify the Committee on Meetings and Program, A.S.M.E., 29 West 39th Street, New York, N. Y.

Annual Meeting, United Engineering Trustees, Inc.

THE annual meeting of United Engineering Trustees, Inc., was held January 26, 1934, when officers for the year were elected: President, H. V. Coes, The American Society of Mechanical Engineers; vice-presidents, George L. Knight, American Institute of Electrical Engineers and The American Society of Mechanical Engineers; and H. P. Charlesworth, American Institute of Electrical Engineers; secretary, Alfred D. Flinn, American Society of Civil Engineers and American Institute of Mining and Metallurgical Engineers; Treasurer, C. P. Hunt, vice-president, Chemical Bank & Trust Company; assistant-treasurer, Arthur S. Tuttle, American Society of Civil Engineers. Members of the 1934 Board are Arthur S. Tuttle, R. M. Roosevelt, W. L. Batt, and George L. Knight (terms expiring 1935); C. W. Hudson, Wm. H. Bassett, Harold V. Coes, and H. P. Charlesworth (terms expiring 1936); and John P. Hogan, H. G. Moulton, D. Robert Yarnall, and Harry R. Woodrow (terms expiring 1937).

The United Engineering Trustees, Inc., is a corporation for the advancement of the engineering arts and sciences in all their branches, including the maintenance of a free public engineering library. It was created in 1904, then known as United Engineering Society, set up by joint action of the four national societies: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and American Institute of Electrical Engineers. The societies have appointed as their representatives eminent members experienced in society affairs, three from each society, twelve in all, who meet monthly except in July and August.

The United Engineering Trustees, Inc., has now two departments established pursuant to joint actions of the Founder Societies: The Engineering Foundation, and the Engineering Societies Library, and an administrative staff; it is titular owner of the Engineering Societies Building with book value of $1,987,794, a depreciation and renewal fund for the building, and trust funds for the Library and The Engineering Foundation, including The Engineering Foundation fund, Library Endowment fund, Henry R. Towne fund, Edward Dean Adams fund, totaling $1,438,295. The Corporation is custodian of the John Fritz Medal fund. The Library is valued at $480,800 and increases in value at the rate of approximately $20,000 a year. The corporation and its departments are tax exempt. It has competent financial custodians and advisers and legal counsel. Its accounts are audited by Certified Public Accountants.

Space in the Engineering Societies Building not occupied by the Founder Societies is allotted to associate societies, and the use of the meeting halls is allowed to other patrons, the revenue reducing the burden of maintenance, operation, and fixed charges. Complete information is given in the "History, Charter, and By-Laws" which may be had on request.

A.S.M.E. Process Industries

AS ANNOUNCED in MECHANICAL ENGINEERING last month (see p. 126), the Executive Committee of the A.S.M.E. Council approved, at its January meeting, the formation of the Process Industries Division to take over the activities of the Process Industries Committee. This committee was formed in 1931 at the request of the Buffalo Section and has gradually developed its activities to the point where the formation of a division was fully warranted. The new division already has a number of active subcommittees. Among these are: heat transfer, air conditioning, drying, sanitation, pulverizing, cotton-seed processing, and a recently formed committee on brewing.

In the sessions which the Process Group held at recent A.S.M.E. meetings there was close cooperation with a number of societies and further cooperation is promised. At the recent A.S.M.E. Annual Meeting, a Heat-Transfer Symposium was held in which the following cooperated: A.S.M.E. Petroleum Division, A.S.M.E. Iron & Steel Division; the American Society of Heating and Ventilating Engineers, the American Ceramic Society, the American Society of Refrigerating Engineers, and the American Society for Testing Materials.

The Executive Committees of the new divisions is as follows: Carlos E. Harrington, University of Buffalo, chairman; Victor Wichum, C. J. Tagliabue Manufacturing Co., vice-chairman; T. R. Olive, assistant editor, *Chemical and Metallurgial Engineering*, secretary; H. D. Munson, Mathieson Alkali Works, Inc.; Charles W. Thomas, consulting engineer; and William Keith McAfee, president, American Ceramic Society.

Fourth International Congress of Applied Mechanics

NINETEEN papers have been promised as America's share in the Fourth International Congress of Applied Mechanics to be held in Cambridge, England, July 3 to 9. The subjects to be discussed at the conference are grouped under four general headings: rational mechanics, mechanics of fluids, materials, waterways. Dr. S. Timoshenko and John M. Lessells constitute the special committee of the Division that has been coordinating American participation in the Congress. Americans planning to attend the Congress are requested to write to the Applied Mechanics Division, A.S.M.E., 29 West 39th St., New York, N. Y., giving the approximate date of their departure.

Demonstration at Taylor Celebration Shows Advance in Metal Cutting

ON DECEMBER 7, 1933, Stevens Institute of Technology, with the cooperation of The American Society of Mechanical Engineers and the Taylor Society, commemorated the fiftieth anniversary of the graduation of Frederick Winslow Taylor, president A.S.M.E. in 1907.

Because of Taylor's contributions to the cutting of metals, a demonstration was arranged to show the great advances made possible in the metal industries by his work. With the assistance of the A.S.M.E. Subcommittee on Metal Cutting Data, a program was worked out and the necessary equipment secured. While Taylor's work was fundamental, and is the basis of all attempts to reduce the art of cutting metals to a science, it was felt that the progress in cutting tools initiated by the discovery of the Taylor-White process of heat treatment was a much more satisfactory basis for such a demonstration than his equally important work on the relation between cutting speeds and the size and shape of the cutting tool, the depth of cut, feed, tool life under cut, and the material cut.

It seemed particularly desirable to follow Taylor's own methods, in so far as possible. For this reason a $^7/_8$ by $1^3/_8$-in. round-nosed tool, such as Taylor used as a standard, and the $^3/_{16}$-in. depth of cut and $^1/_{16}$-in. feed which he used when comparing the quality of tools, or the machinability of the metal cut, were adopted. Because of time limitations it was not possible to use cutting speeds which would give tool failure in 20 min, as recommended by Taylor. Instead, cutting speeds were used which would give tool failure in approximately 10 min.

With the heavy engine lathe, loaned by the Niles Tool Works Co., there was no difficulty in getting a close approximation to any desired

speed and in taking a cut of the size desired without any trace of distress.

The metal cut was a billet of medium-carbon steel, carefully heat-treated to insure uniformity, and was donated for the demonstration by the United States Steel Corporation.

CUTTING TESTS MADE WITH FIVE TOOLS

Comparative demonstration cutting tests were made with five tools. The carbon tool steel of which one tool was made was of a grade now on the market, similar to the Jessop carbon tool steel, No. 85 in folder No. 20 in Taylor's "On the Art of Cutting Metals." Much of Taylor's early work was done with a steel of this general type.

Two tools were made of a self-hardening steel which is no longer on the market, although it conforms closely to steel No. 26, folder No. 20, and which was developed by the Sanderson Tool Steel Company. Sanderson furnished nearly 100 tons of this steel to the Bethlehem Steel Company in 1900 and a large part was probably used in the demonstration of the Taylor-White process at the Paris Exposition in that year. In the demonstration tests at Stevens, one of the tools made of this steel was given a heat treatment such as was customary before the discovery of the Taylor-White process, while the other was treated according to that process.

The fourth tool was made of steel having substantially the same analysis as tool steel No. 1, folder No. 20, in Taylor's "On the Art of Cutting Metals," of which Taylor stated: "This is the best high-speed-steel tool with which we have experimented."

The fifth tool, which was included to make possible a comparison with modern practise, was made from a good modern 18-4-1 steel, such as is being used at present for approximately 65 per cent of the metal cutting done in this country.

All tool steels were furnished by the Crucible Steel Company, which made up special heats of the self-hardening and Taylor No. 1 steels, as these have not been used commercially for many years.

To insure tool uniformity, the tools were heat-treated by Brown & Sharpe in Hayes electric box-type furnaces, in which the furnace atmosphere was controlled at approximately 8 per cent CO, with the exception of the carbon steel and low-heat self-hardening steel tools, which were hardened in a salt bath.

For the five tools, in the order described, the average of the results in feet per minute of cutting speed with a tool life of 30 min were as follows: 11.7, 13.5, 49.9, 75.2, and 78.1

CARL G. BARTH TELLS OF TAYLOR

Robt. T. Kent presided at the demonstration. L. P. Alford spoke on some of the economic effects of Taylor's work, and Carl G. Barth related reminiscences of his associations with Taylor, and demonstrated the Barth metal-cutting slide rule.

At the close of the demonstration on Saturday, Mr. Barth very generously presented to the A.S.M.E. the depth-of-cut, and the tool-contour gages which he had used in 1902 and 1903 in conducting much of the experimental work which Taylor incorporated in his work "On the Art of Cutting Metals." These gages, which are of very real historical interest, will be of great value in the conduct of such experimental work on the cutting of metal as the Subcommittee on Metal Cutting Data, of the Special Research Committee on the Cutting of Metal, proposes to carry on in the near future.

Coming Meetings of A.S.M.E. Local Sections

Baltimore: March 1. Engineers Club at 8:15 p.m. Joint Meeting with the A.S.C.E. "A Humanitarian Subject," by Dr. Mitchell, assistant professor of political economy, Johns Hopkins University.

Detroit: March 28. Dinner at 6:00 p.m. Inspection trip at 7:00 p.m. Talk at 8:30 p.m. Meeting will take place at the plant of the Great Lakes Steel Corporation, Detroit (Ecorse), Michigan. Subjects: "Romance of Iron and Steel," by Julius A. Clauss, chief engineer, Great Lakes Steel Corporation; "Steel and Its Relation to the Automotive Industry," by Prof. Wm. H. Smith, president, General Ore Reduction Co.

Hartford: March 13. State Trade School, 110 Washington St. at 8:00 p.m. Subject: "Cemented Carbide-Cutting Tools," by Malcolm F. Judkins, chief engineer, Firthite Division, Firth-Sterling Steel Co.

Kansas City: March 16. Kansas City Power and Light Co. Building at 8:00 p.m. Subject: "Liquid Dielectrics," by Professor John B. Whitehead, Johns Hopkins University, and President of the American Institute of Electrical Engineers.

Louisville: March 15, 1934. Joint Meeting with the Student Branch of the University of Louisville. Meeting will be held at 4:00 p.m. at the Speed Scientific School, University of Louisville. Subject: "High-Compression Engines and Fuels," by R. R. Faller, Ethyl Gasoline Corporation, New York City.

New Britain: March 7. Bristol, Conn. Subject: "Ball Bearings."

Norwich: March 21. Arcanum Club, Norwich, Conn. at 8:00 p.m. Subject: "Welding," by E. R. Fish, chief engineer, boiler division, The Hartford Steam Boiler Inspection & Insurance Co.

Ontario: March 9. University of Toronto at 8:15 p.m. Subject: "Centrifugal Pumps, Motors, and Electric Control," by P. L. Evans, Pump Designer—Babcock-Wilcox and Goldie-McCulloch, Ltd.

Philadelphia: March 27. Engineers Club, 1317 Spruce St., Philadelphia at 8:00 p.m. Subject: "Fuels."

Providence: March 6. Probably a meeting with the Student Branch members of Rhode Island State College.

Toledo: March 15. Mr. Van Doern will talk on "Art in Machine Design."

Waterbury: March 15. Waterbury Club at 12:15 noon. Subject: "Protective Value of Plated Coatings on Metals," by Dr. William Blum, electro chemical director of U. S. Bureau of Standards.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after March 26, 1934, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Members desiring further information, or having comments and objections, should write to the Secretary of the A.S.M.E. at once.

NEW APPLICATIONS

ALGERI, DANTE J., Brooklyn, N. Y.
ANDERSON, NORMAN O., East St. Louis, Ill.
BANTA, T. C., East Chicago, Ind.
BLAKE, JOEL W., Oklahoma City, Okla.
BONDY, WINFIELD S., Brooklyn, N Y. (Rt & T)
BRIGGS, WILLIAM C., JR., Lynchburg, Va.
BRIGHTENBURG, JOHN W., Washington, D. C.
BROWN, NORTON M., Lincoln Park, Mich.
BUCHMAN, ALEXANDER H., Shanghai, China
CONLEY, JOHN W., Detroit, Mich.
DEALUNE, HERBERT L., New Orleans, La.
FERGUSON, ALLAN R., New Kensington, Pa.
GLASGOW, CLARENCE O., Enid, Okla.
GUARINI, EUGENE J., Woodhaven, Queens, L. I.
GUGGENBUEHLER, CARL F., Newark, N. J.
HENSHAW, FRANKLIN, Scarsdale, N. Y.
KOERBER, JEROME ANTHONY, JR., Philadelphia, Pa.
LARSON, FRANCIS W., Sacramento, Calif.
MATTHEWS, REGINALD GEO., Orange, N. J. (Rt)
MCBEE, EDGAR L., Toledo, Ohio
MCOWEN, J. BERRY, Buffalo, N. Y.
MEYER, ALVIN D., Endwell, N. Y.
NELSON, HARRY F., Detroit, Mich.
OKNER, BERNARD S., Chicago, Ill.
PEACH, JOHN WELFORD, Baltimore, Md.
PESKIN, LEONARD C., Cambridge, Mass.
PETTIT, ALBERT R., Rancocas, N. J. (Rt & T)
ROBERTS, H. L., Corsicana, Tex.
ROBERTS, JOHN, Montreal, Quebec, Canada
ROEVER, FREDERICK HAMILTON, St. Louis, Mo.
SEXTON, SAMUEL BUDD, 3RD, Baltimore, Md.
SHEETS, GILBERT STANLEY, Lima, Ohio
SIZER, HAROLD S., Pawtucket, R. I.
SMITH, MARK E., Erie, Pa. (Rt & T)
VALENTINE, H. W., Alameda, Calif.
VAN VALKENBURGH, L. D., SR., Pedro Miguel, Canal Zone
WELCH, CHESTER W., East Lynn, Mass.
WHITE, DAN I., Chicago, Ill.
WILLIAMS, FRANK S. G., New York, N. Y.
YOUNG, PETER J., JR., Corning, N. Y.

CHANGE OF GRADING

Transfers from Associate-Member

FULLMER, IRVIN H., Washington, D. C.
OZLEY, G. R., Tarrant, Ala.

Transfers from Junior

BAUER, ERNEST K., Thompsonville, Conn.
DALRYMPLE, A. W., Berranquilla, Colombia, S. A.
KEEN, GEORGE W., Halethorpe, Md.
MILLER, FRANK WM., Chestnut Hill, Philadelphia, Pa.
YOST, CHARLES J., Haddonfield, N. J.